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■ *Research Paper*

Rethinking Systems Thinking: Learning and Coevolving with the World

David Ing*

Department of Industrial Engineering and Management, School of Science and Technology, Aalto University, Espoo, Finland

Much of systems thinking, as commonly espoused today, was developed by a generation in the context of the 1950s–1980s. In the 2010s, has systems thinking changed with the world in which it is to be applied? Is systems thinking *learning* and *coevolving* with the world? Some contemporary systems thinkers continue to push the frontiers of theory, methods and practice. Others situationally increment the traditions of their preferred gurus, where approaches proven successful in prior experiences are replicated for new circumstances. Founded on interactions with a variety of systems communities over the past 15 years, three ways to rethink systems thinking are proposed:

1. 'parts and wholes' snapshots → 'learning and coevolving' over time
2. social and ecological → emerged environments of the service economy and the Anthropocene
3. episteme and techne → phronesis for the living and nonliving

These proposed ways are neither exhaustive nor sufficient. The degree to which systems thinking should be rethought may itself be controversial. If, however, systems thinking is to be authentic, the changed world of the 21st century should lead systems thinkers to engage in a reflective inquiry. Copyright © 2013 John Wiley & Sons, Ltd.

Keywords systems thinking; learning; coevolution; world

INTRODUCTION: IS SYSTEMS THINKING LEARNING AND COEVOLVING WITH THE WORLD?

The rise of systems thinking can be correlated with the founding of the Society for General Systems Research—the precursor for today's International Society for the Systems Sciences—in 1956. Much of conventional wisdom about systems thinking was influenced by luminaries between the 1950s and 1980s. Prominent names include presidents of the ISSS between 1971 and 1999: Stafford Beer, Margaret Mead, James Grier Miller, Gordon Pask, Kjell Samuelson, Heinz von Foerster, Sir Geoffrey Vickers, Richard F. Ericson, Brian R. Gaines, Robert Rosen, George Klir, John N. Warfield, Karl Deutsch, Bela H. Banathy, John A. Dillon, Peter B. Checkland,

*Correspondence to: David Ing, Department of Industrial Engineering and Management, School of Science and Technology, Aalto University, Espoo, Finland.
E-mail: isss@daviding.com

Russell L. Ackoff, Ilya Priogine, C. West Churchman and Len R. Troncale. These figures can each represent centres in larger communities of thought, inquiring into systems both from an interdisciplinary perspective and with the disciplines in which they have roots.

Systems thinking embraces advances in science, with a trajectory rooted in decades of theory, methods and practice. As with any community of interest, the balance between following the knowledge left behind by a guru versus breaking new ground to supersede his or her artefacts can be a challenge. (Ackoff and Strümpfer, 2003).

As we look back at the rich legacy of systems thinkers that preceded us, three ways to look forward to rethink systems thinking are proposed.

1. systems thinking framed as 'parts and wholes' snapshots rethought with processes of 'learning and coevolving' over time
2. systems thinking framed as social and ecological rethought with emerged environments of the service economy and the Anthropocene
3. systems thinking framed as episteme and techne rethought to include phronesis for both the living and nonliving

These proposals are intended to guide further reflection on the future of systems thinking, standing on the shoulders of giants who precede us. This calls not for an inductive-consensual approach to the sciences of systems but instead for continuation of dialogues in which frontiers of knowledge will continue to open. The proposals are neither exhaustive nor sufficient, and similar encouragements have been expressed by other systems leaders in the past (Troncale, 2009).

The contribution that these three proposals make, in the 2010s, is in specificity. The world of this decade could use some help from systems thinkers and may welcome an engagement if a systems approach is seen as relevant and practical.

'PARTS AND WHOLES' SNAPSHOTS → 'LEARNING AND COEVOLVING' OVER TIME

In comparison with the world of the 1960s–1980s, the 21st century seems to run much faster. Globalization and the rise of the Internet have led many to subscribe to the sense that 'the world is flat', as information and communication technologies have made geographic distances less relevant (Friedman, 2005). The incidence of 'black swan' events characterized by low probability, extreme impact and retrospective predictability has led many to reconsider their views on how the world works (Taleb, 2007). Systems thinking built on a world with presumed stability deserves to be rethought when change is the norm.

Systems Thinking is a Perspective on Wholes, Parts and Their Relations

If systems thinking is to be rethought, which definition of systems thinking should we use? Systems thinking can be seen as a system of ideas, with members of the community of interest emphasizing and de-emphasizing parts of the whole. Let us use this description: systems thinking is a perspective on wholes, parts and their relations.

The Most Basic Relations in Systems Thinking Are Function, Structure and Process

Briefly, function is contribution of a part to the whole; structure is an arrangement in space; and process is an arrangement in time. These three relations are essential to systems thinking.

> … a *design* approach dealing *iteratively* with *structure*, *function*, and *process* is the 'enabling light' of systems methodology.
>
> *Structure* defines components and their relationships, which in this context is synonymous with input, means and cause. *Function* defines the outcome, or results produced, which is also synonymous with outputs, ends, and effect. *Process* explicitly defines the sequence of activities and the know-how required to produce the outcomes. Structure, function, and process, along with their containing environment, form the *interdependent* set of variables that define the whole.
>
> The notion of the whole can be applied to any context to generate a *context-specific* initial set of assumptions for the starting point of inquiry. These assumptions can be verified and enriched by successive elaboration of structure,

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> function, and process in a given environment to produce a desired approximation of the whole. Use of all three perspectives of structure, function, and process as the foundation of a holistic methodology can be justified on both intuitive and theoretical grounds. (Gharajedaghi, 1999, 110)

The philosophy underlying these three relations has a long history, dating back to the ancient Greeks. Function is related to teleology, causality (with Aristotle) (Falcon, 2012) and purpose (Ackoff and Emery, 1972). Structure is related to substance, and those things that do not change, with Parmenides and Plato (Robinson, 2013). Process is related dynamics, and reality of change, with Heraclitus (Seibt, 2012). A parallel stream of systems thinking has developed in Chinese philosophy (Gu and Zhu, 2000; Zhu, 2000; Pan *et al*., 2013).

Systems Thinking May Be Merely Espoused or Authentic

Where does espoused systems thinking contrast to authentic systems thinking? As a practical description, Ackoff contrasted systems thinking as synthesis preceding analysis, with Machine-Age thinking where the order is reversed. Many self-espoused systems thinkers fail in emphasis on the containing whole, instead focusing only on part–part interactions in a reductive style.

> Synthesis, or putting things together, is the key to systems thinking just as analysis, or taking them apart, was the key to Machine-Age thinking. Synthesis, of course, is as old as analysis—Aristotle dealt with both—but it is taking on a new meaning and significance in a new context just as analysis did with the emergence of the Machine Age. Synthesis and analysis are complementary processes. Like the head and tail of a coin, they can be considered separately, but they cannot be separated. Therefore, the differences between Systems-Age and Machine-Age thinking derives not from the fact that one synthesizes and the other analyses, but from the fact that systems thinking combines the two in a new way.
>
> Systems thinking reverses the three-stage order of Machine-Age thinking; (1) decomposition of that which is to be explained, (2) explanation of the behavior or properties of the parts taken separately, and (3) aggregating these explanations into an explanation of the whole. This third step, of course, is synthesis. In the systems approach there are also three steps:
>
> 1. Identify a containing whole (system) of which the thing to be explained is a part.
> 2. Explain the behavior or properties of the containing whole.
> 3. Then explain the behavior or properties of the thing to be explained in terms of its role(s) or function(s) within its containing whole.
>
> Note that in this sequence, synthesis precedes analysis. In analytical thinking the thing to be explained is treated as a whole to be taken apart. In synthetic thinking the thing to be explained is treated as part of a containing whole. The former reduces the focus of the investigator; the latter expands it. (Ackoff, 1981, 16–17)

From this foundation, two subtleties can be expanded. Firstly, although wholes and parts are emphasized in this simple introduction, relations of wholes with other wholes can also be important (Angyal, 1941; Trist, 1992). Secondly, although most people will first think of wholes and parts as arrangements in space (i.e. structure), the arrangements over time (i.e. process), with the possibility of learning and coevolving, are no less important.

Parts and Wholes of Systems May or May Not Have Purpose

Although systems thinking can be used to describe a variety of types of systems, parts and wholes may be categorized by their capacity to pursue ends (Ackoff and Emery, 1972). A purposeful system is ideal seeking, that is, pursuing an end that is believed to be unattainable, but towards which progress is possible during and after the period planned for. A purposive system is goal seeking, that is, pursuing an end that is expected to be attained within a period covered by planning. Machines can be programmed to be goal seeking. Human beings are believed to be ideal seeking.

In the context of purposes, Table 1 summarizes three types of systems and models, and one meta-system that contains the others as parts (Ackoff and Gharajedaghi, 1996). Deterministic

Table 1 Types of systems and models (Ackoff and Gharajedaghi, 1996)

Systems and models	Parts	Wholes
Deterministic	Not purposeful	Not purposeful
Animated	Not purposeful	Purposeful
Social	Purposeful	Purposeful
Ecological	Purposeful	Not purposeful

systems and models, such as mechanisms and plants, are purposeful in neither their parts nor their wholes. Animated systems, such as organisms with an ability to move, are not purposeful in their parts yet can demonstrate choice in their wholes. Social systems have animated organisms as parts that are purposeful, and the social collective as a whole is purposeful. Ecological systems contain mechanistic, organismic and social systems as parts but have no purposes of their own as a whole.

Systems thinking includes change. Purposeful or purposive behaviour may be exhibited by some types of systems, but not others. Mistyping a systems model can lead to representations that lead to misguided expectations on their behaviour.

Learning and Coevolving Are Features of Systems Thinking in Living and Nonliving Systems

How does emphasizing the dimension of time influence thinking about systems? In the systems tradition, two relations have been well defined. Learning reflects changes to a system in response (or anticipation) to its environment. Coevolving reflects changes in one whole (e.g. a species) to another whole (e.g. another species). These relations can be expressed for both living and nonliving systems.

Learning in Systems Has Been Categorized as Four Types

Bateson developed his appreciation for types of learning while observing dolphins (Visser, 2003).

- 'Zero learning' was the label for a dolphin that would not respond to training stimuli.
- 'Learning I', or proto-learning was exhibited by dolphins who could learn to respond to a stimulus in a repeatable pattern (e.g. doing a trick to receive the reward of a fish).
- 'Learning II', also known as deutero-learning or double-loop learning, rewarded not for repeating a old trick, but instead for exhibiting a new trick. Dolphins proficient in proto-learning would enter a double-bind pattern of frustration at not being rewarded for an old trick and might (or might not) learn that rewards were being given only for new tricks.
- 'Learning III', also known as trito-learning or triple-loop learning, involves the ability to cope with entirely differently sets of alternatives. Beyond dolphins, I have observed this capability in my sons, who were educated in Canadian public schools and then attended 2 years of immersion in a university in Beijing without any prior experience with the Mandarin language. They have proven to be able to easily adapt to new cultural and linguistic situations (e.g. Tokyo and the Japanese language) without difficulty.
- 'Learning IV', as phylogenesis (of tribe or species) with ontogenesis (of an individual living being), can be best characterized as genetic change, beyond the capability of human will, but not beyond the wisdom of evolution in nature.

More formally,

> Change denotes process. But processes are themselves subject to 'change'. The process may accelerate, it may slow down, or it may undergo other types of change such that we shall say that it is now a 'different' process. (Bateson, 1972, p. 283)
>
> *Zero learning* is characterized by specificity of response, which—right or wrong—is not subject to correction.
>
> *Learning I* is *change in specificity of response* by correction of errors of choice within a set of alternatives
>
> *Learning II* is *change in the process of Learning I*, e. g., a corrective change in the set of alternatives from which choice is made, or it is a change in how the sequence of experience is punctuated.
>
> *Learning III* is *change in the process of Learning II*, e.g., a corrective change in the system of sets of alternatives from which choice is made. (We shall see later that to demand this level

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> of performance of some men and some mammals is sometimes pathogenic.)
>
> *Learning IV* would be *change in Learning III*, but probably does not occur in any adult living organism on this earth. Evolutionary process has, however, created organisms whose ontogeny brings them to Level III. The combination of phylogenesis with ontogenesis, in fact, achieves Level IV. (Bateson, 1972, 293)

In nature, learning of all four types can occur within and amongst systems simultaneously. Learning is generally accepted as a feature of animated systems and social systems. Sociocultural systems are information bonded as well as energy bonded (Buckley, 1968; Gharajedaghi, 1999). Information about changes in the environment can lead to conscious and wilful changes in behavior and/ or unconscious and genetic evolution of a species. Human systems, as individuals or groups with will, may choose to ignore or even deny learning of one or more types.

Nonliving Systems Can Also Be Described as Learning, When the System of Interest Is Shifted

Bateson's definitions of learning are robust across living and nonliving systems. This is demonstrated in the shift of perspective in *How Buildings Learn* (Brand, 1994). In our usual anthropocentric view, we conventionally think about a home with the family as the system, and the built environment of the house as their environment. An alternative view places the house as the system, and the family as part of the environment. Although a row of houses originally constructed in the same project may begin with the same floor plans and materials, they can 'learn' over time according to the wants and needs of the occupants. For families who like the house 'as-is', the learning is small; for families where the size and age of the occupants change over time, the learning may be reflected in minor redecorating or major renovations and restructuring.

Brand introduced the 'shearing layers' or 'pacing layers' to reflect that change can occur at varying rates within a building. The *site* is the most permanent layer in a building and outlasts any building constructed on it. The *structure* is the next slowest-changing layer, as the load-bearing walls on which other layers are hung. Outside, the *skin* of exterior surfaces covers the structure to protect against climate. Inside, *services* such as plumbing, electrical wiring and ventilation are placed inside walls. The *space plan* includes non-load-bearing walls, to divide up open areas into rooms. The fast-changing layer in a building is the *stuff*, also known as furniture.

This perspective concretely illustrates a lesson: the pace of change within a layer is constrained by the containing layer. Brand cited O'Neill *et al*. (1986):

> The insight is this: 'The dynamics of the system will be dominated by the slow components, with the rapid components simply following along'. Slow constrains quick; slow controls quick. [….] Still, influence does percolate in the other direction. [….] The speedy components propose, and the slow dispose. [….] Ecologist Holling points out that it is at the times of major changes in a system that the quick processes can most influence the slow.
>
> The quick processes provide originality and challenge, the slow provide continuity and constraint (Brand, 1994, 17).

Here is a riddle on which to test systems thinkers: which comes first, structure or process?

In a private conversation in 2006, G.A. Swanson said that process comes before structure. Think about structure as the slowest-changing process in the system. The most permanent structure in one person's system of ideas could be contained within the whole of another person's system of ideas. Introducing the dimension of time can be a challenge to some people. All parts of a system do not necessarily learn at the same rate.

Originating as Two-species Interactions, Coevolution Can Also Be Specified for Both The Living and Nonliving

The term 'coevolution' was first popularized in 1974 by Stewart Brand with the publication of *CoEvolution Quarterly*, named by his interest in the work of a series of ecologists: 'Ed Ricketts (via John Steinbeck's Monterey books), Aldous Huxley (in print and in person), Paul Ehrlich, and last and deepest, Gregory Bateson' (Brand, 1986, 3). The 1974 republication of a 1970 article

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for a 1968 symposium proposed coevolution as a new way of looking at the properties of communities (Ehrlich, 1986).

Coevolution was described in five interactions: (i) plants and herbivores; (ii) predator–prey; (iii) parasite–host; (iv) mimicry; and (v) plants and pollinators. In the first type, the interaction between the *Lotus corniculatus* plant and blue butterfly *Polyommatus icarus* was studied. The plants contain cyanogenic glucosides that produce poisonous hydrogen peroxide when the plants are injured. The larvae of the butterfly can consume the plant, as they can detoxify the cyanide. These species of plant and butterfly coevolve. These plants do not go extinct, as herbivores can choose other species of plants that are not poisonous. Two-species population interactions may be categorized with respect to benefits or inhibitions and then generalized from biology to other systems. Table 2 extends a typology of general natures of interaction (Odum, 1983, 369).

Nine types of interactions can be abstracted into four categories:

- With neutralism, type 1, neither population affects the other.
- 'Negative interactions' for both populations are observed in types 2–4, including competition (with either direct interference or resource use) and amensalism.
- Both 'positive interactions' and 'negative interactions' mix benefits and inhibitions for both populations, in types 5 and 6, including parasitism and predation.
- 'Positive interactions' for both populations are observed in types 7–9, with commensalism, protocooperation and mutualism.

Whereas these two-species interactions are presented at points in time, coevolution suggests change over time. In biology, the change over time might be described as purposive—particularly towards survival of a species—but not purposeful, that is, ideal seeking at the level of a population or community.

Learning and coevolving are ways in which systems can react or respond to changes in their environment. Generalizing these features across living and nonliving systems raises questions of human will. In the next section, the possibility that human beings might be able to completely redesign worlds—as a perspective larger than a system and environment—is considered.

Table 2 Two-species population interactions (extended from E.P. Odum, 1983)

	Type of interaction	Species *1*	Species *2*	General nature of interaction
	1. Neutralism	0	0	Neither population affects the other
'Negative interactions', types 2 through 4	2. Competition: direct interference type	–	–	Direct inhibition when common resources are in short supply
	3. Competition: resource use type	–	–	Indirect inhibition when common resources are in short supply
	4. Amensalism	–	0	Population 1 inhibited, 2 not affected
Both 'positive interactions' and 'negative interactions', types 5 and 6	5. Parasitism	+	–	Population 1, the parasite generally smaller than 2, the host
	6. Predation (including herbivory)	+	–	Population 1, the predator, generally larger than the host
'Positive interactions' types 7 through 9	7. Commensalism	+	0	Population 1, the commensal, benefits, while 2, the host, is not affected
	8. Protocooperation	+	+	Interaction favourable to both but not obligatory
	9. Mutualism	+	+	Interaction favourable to both and obligatory

Legend: 0 indicates no significant interaction; + indicates growth, survival or other population attribute benefited (positive term added to growth equation); – indicates population growth or other attribute inhibited (negative term added to growth equation).

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Paths for Learning and Coevolving Can Include Complexifying and Decomplexifying

Can systems purposively learn or coevolve? Natural systems may learn and coevolve either through laws of science (e.g. biochemistry) or instinct (e.g. with insect behaviour). Human systems have an additional feature of will, so that we can shape desired futures. Even when we espouse either incremental or transformation change, some systems resist efforts to learn and/or coevolve.

Purposive Redesign Occurs Either by Change(s) in the System, Change(s) in the Environment or Both

Living systems differ from nonliving systems in behaviors that are goal directed. From a systems perspective, goals can be achieved in one of two ways: (i) the system changes in response to its environment; or (ii) the system remains static while the environment changes. Directive correlation in the game of football (i.e. soccer to North Americans) is described with two situations: either (i) the player moves towards the ball; or (ii) the player positions so that the ball comes to him (Sommerhoff, 1969, 174–186). These two situations are simplifications of the reality where both the player and the ball are changing position in real time.

In a summary describing directive correlation, learning and coevolving in living systems present three features additional to those in nonliving systems.

> 1. The distinctive organization of living systems manifests itself in the goal-directedness of their activities. [….]
>
> 4. Goal-seeking is not the same as equilibrium-seeking, nor is it co-extensive with feedback control.
>
> 5–6. Directive correlation enables many biological key concepts … [including] adaptation, regulation, co-ordination, learning, instinct and drive. (Sommerhoff, 1969, 201–202)

Thus, living systems demonstrate goal-oriented behavior that nonliving systems do not. The goals may or may not be coincident with an equilibrium or a feedback control. Goals enable living systems, as individuals and as groups, to adapt and learn.

Effective Purposive Change in a System Can Depend on the Causal Texture of the Environments

If we define a system of interest to be a living system that is goal directed, its environment can include both living and nonliving parts. A system and its environment do not represent the whole world. In causal texture theory, a system and its environment are described as a field, which is a whole amongst other wholes (Ramírez *et al.*, 2008).

> Causal texture is an emergent property of the whole field and concerns the behaviour of all systems within it. The causal texture of a field sets conditions on how these systems and their shared environments transact (Selsky *et al.*, 2007, p. 74).

Figure 1 shows the simplest representation of a single field, with a system labelled as ‘1’ and the environment labelled as ‘2’. Linkages between those parts are labelled as L_{11}, L_{12}, L_{21} and L_{22}.

A system of interest that is goal directed could alternately be encouraged or inhibited by its environment. As parts of the field, change simultaneously occurs as follows: (i) with parts within the system interacting as L_{11}; (ii) with the system acting on the environment as L_{12}; (iii) from the environment influencing the systems as L_{21}; and (iv) with parts of the environment interacting as L_{22}.

Four possible links between a system and its environment exist:

1. L11 (read as ‘El one, one’, not as ‘El eleven’) denotes links that remain internal to a system.
2. L12 links the system to its environment–system outputs, related to the planning function.
3. L21 links the environment to the system–system inputs, related to the learning function.
4. L22 denotes links between elements of the environment itself and that occur independently of the system (Ramírez *et al.*, 2008, 19).

The extended fields of directive correlations were categorized into four types: (I) random placid; (II) clustered placid; (III) disturbed reactive; and (IV) turbulent. Table 3 highlights some of the wisdom gained from the original research by Emery and Trist in 1965, continuing through to the causal textures research by 2008.

The four causal textures have been described in a metaphor of a surface with food and competitors.

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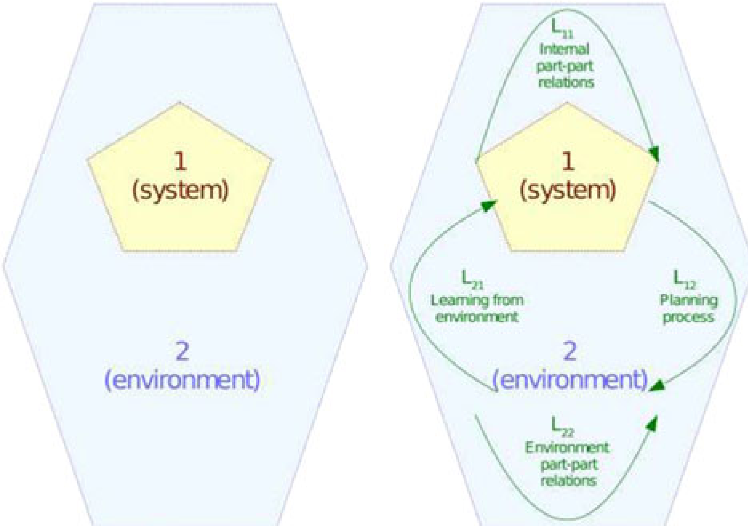

Figure 1 A system and environment connect together as a field, with links emerging a causal texture

I. Goals (food) and noxiants (bads) are randomly distributed. Actors should know the system, with the ideal of homonomy (i.e. a sense of belonging). Learning involves conditioning, and planning is tactical (e.g. if you need food, move!)

II. Goals and noxiants are lawfully distributed. Actors should know the system and effects of action, with the ideal of nurturance (i.e. caring for the field). Learning involves meaning, and planning is tactical and strategic (i.e. if you need food, move; there's lots of food, so encounter a competitor, just move somewhere else).

III. Goals and noxiants are lawfully distributed as in type II, but two or more systems are competing for the same resources. Actors should know the system, the effects of action and the changes resulting from learning, with the ideal of humanity (in the broadest sense, with the context of limited resources). Learning is problem solving, and planning is tactical with operational strategies (i.e. if you need food, movements should take competitors into account).

IV. The field is dynamic, as type III plans leads to emergent and unexpected outcomes. In addition to knowing about the system, action and learning, the attention shifts to appreciating the environment. The ideal is beauty, as the multiple systems and environments should fit together naturally. Learning is puzzle solving of nonlinearities, and planning is active adaptive planning (i.e. the field is in motion, and when you move, you may add to shaking the ground).

In circumstances where collective learning and coevolving are desirable, differences in the appreciation of the causal texture lead to conflict. If one party believes that resources are plentiful whereas others see resource as constrained, the nature of their plans will differ. If one party believes that changes in their system have no impact on their environment whereas others see the entire field as turbulent, the nature of their plans will differ. The perceived values of learning, and each party's inclination to coevolve cooperatively, may lead to irreconcilable clashes.

Systems Resistant to Change May Be Complexified for Greater Efficiency or Decomplexified for Greater Sustainability

Living systems may resist change. In human systems, the resistance to change may be recognized in the social reproduction of structure, for example, structuration theory (Giddens, 1986), or in the social reproduction of practice, for example, reflexive sociology (Bourdieu and Wacquant, 1992). Hierarchy theory proposes that systems can be transformed either through complexification or decomplexification.

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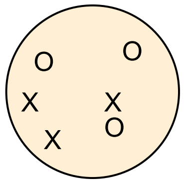
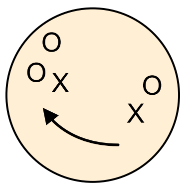
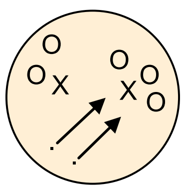
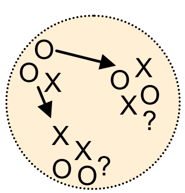
Table 3 The causal texture of social environments: extended fields of directive correlation

		Description	Elements to know	Ideals	Forms of learning	Forms of planning
Type I: random placid		Goals and noxiants randomly distributed. Strategy is tactic. ‘Grab it if it’s there’. Largely theoretical of micro, design, for example, concentration camps, conditioning experiments. Nature is not random.	System	Homonomy—sense of belonging	Conditioning	Tactics
Type II: clustered placid		Goals and noxiants are lawfully distributed—meaningful learning. Simple strategy—maximize goals, for example, use fire to produce new grass. Most of human span spent in this form. Hunting, gathering, small village. What people mean by the ‘good old days’.	System, action	Nurturance—caring for	Meaningful	Tactics/strategies
Type III: disturbed reactive		Type 2 with two or more systems of one kind competing for the same resources. Operational planning emerges to out-manoeuvre the competition. Requires extraknowledge of both Ss and E. E is stable so start with a set of givens and concentrate on problem solving for win-lose games. Need to create instruments that are variety reducing (foolproof)—elements must be standardized and interchangeable. Birth of bureaucratic structures where people are redundant parts. Concentrate power at the top—strategy becomes a power game.	System, action, learning	Humanity—in the broadest sense	Problem solving	Tactics/operational strategies
Type IV: turbulent		Dynamic, not placid/stable. Planned change in type 3 triggers off unexpected social processes. Dynamism arises from the field itself, creating unpredictability and increasing relevant uncertainty and its continuities. Linear planning impossible, for example whaling disrupted reproduction, people react to being treated as parts of machine. Birth of open systems thinking, ecology, and catastrophe theory.	system, action, learning, environment	Beauty—includes fitting together naturally	Puzzle-solving	Active adaptive planning

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A living system may evolve by either horizontally elaborating its structural complicatedness in a flat hierarchy or vertically elaborating its organizational complexity in a deep hierarchy (Allen *et al.*, 1999, 2003). The flat hierarchy, as a complicated system of systems, operates with resources at low gain and is therefore more sustainable. The deep hierarchy, as an integrated complex system, operates with resources at high gain, with greater overall efficiency (Allen *et al.*, 2009, 2010). Although greater efficiency is often touted as a virtue, the risk of collapse of a complex systems is greater than that of a loosely coupled complicated structure. The Roman empire grew weaker as it conquered lands farther from its centre, and the governing structure collapsed. The Byzantine empire, with multiple centres, had a longer (although arguably less illustrious) civilization (Tainter, 1990).

An oncoming collapse may be denied by some analysts, whereas others with deeper foresight clearly see trends towards an undesirable future. A society enjoying the benefits of a complex system may have the excess resources to dedicate towards transformation via a 'prosperous way down' into a more sustainable future, if it does not procrastinate until investment becomes futile (Odum and Odum, 2006).

Section 2 has reviewed the heritage of systems thinking. In Section 3, some significant changes in the world that should lead to rethinking systems thinking are discussed.

SOCIAL AND ECOLOGICAL → EMERGED ENVIRONMENTS OF THE SERVICE ECONOMY AND THE ANTHROPOCENE

In which ways should systems thinking be rethought? One way is to respond to changes in the environment for systems thinking itself.

In the 1950s–1960s, the rise of systems thinking correlates with advances in understanding physical systems. The foundational concepts of relations between parts were established, mostly in a mechanistic paradigm. Similes of computers as electronic brains and of athletes as locomotives illustrate the way that systems thinking was described.

In the 1970 and 1980s, systems thinking was challenged to recognize that that human systems do not behave like machines. The socio-psychological systems perspective describes human individuals in relation to groups and institutions; the socio-technological systems perspective describes human individuals and groups in relation to technologies; the socio-ecological systems perspective describes human individuals and groups in relation to rapid changes in society. With purposes in their parts and wholes, systems thinking developed a stronger appreciation of social systems thinking.

In the 1990s and 2000s, systems thinking was at the foundation of awareness about threats to the ecology. The natural world behaves neither as a machine nor as a social system. As environments in which living organisms change, some species have become stressed, whereas others are driven into extinction. Resilience thinking and panarchy emerged to describe cycles of growth and decline, as systems at varying scales coevolve.

Now, in the 2010s approaching the 2020s, systems thinking has the opportunity to contribute to the scientific understanding of issues in our world. Advances in two domains build on the traditions of systems thinking from the 20th century. Firstly, the shift of the developed world from manufacturing economies to service economies has opened up research into service systems science and service systems thinking. Secondly, the epoch of temperate climate enjoyed in the Holocene is transitioning into an Anthropocene where human activity has lead to irreversible changes in the natural ecology. Are the traditions of systems thinking a foundation on which new knowledge is to be developed or an anchor where prior research becomes fundamentalist dogma?

Systems Thinking Will Change When Resilience Is Low, with Learning and Coevolving across Slower and Faster Scales

Does the community of systems thinkers perceive changes in the environment that would lead to changes in the field? Scholarship in the systems movement—as 'systems thinking', 'systems science',

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'systems design' and 'soft systems'—seems to have exhibited either a growth plateau or an early decline for some years (Ramírez and Paltschik, 2013). In comparison with the 'peak oil' hypothesis, this pattern could mean the following: (i) finds in the systems movements are exhausted; (ii) growth in the systems movement may be restored with new technologies; or (iii) the temporary trend will soon turn around, with riches in the systems movement yet untapped. The systems movement could therefore be described as follows: (i) systems thinking has become so mainstream that minimal additional development of the field is required; (ii) systems thinking is in a cycle where new techniques and solution approaches could soon be on the rise again; or (iii) systems thinking, having solved some classes of problems, can now turn to even larger messes.

Systems thinking, as a system itself, may be at a point where it is receptive or resistant to change. That point can be described reflexively using the perspectives of resilience thinking and panarchy.

From the perspective of ecological resilience, the field of systems thinking perceived as highly resilient will be difficult to change. A system strong in resilience has resources accumulated and available for transformation (i.e. moving from exploitation r to conservation K). A system weak in resilience frees resources for innovation (i.e. moving from release Ω to reorganization α) (Holling, 2001). From the perspective of ecological resilience, those who want to maintain a status quo will work towards strengthening the resilience of a system; those looking for change will look for an opportunity to act when resilience is low.

From the perspective of panarchy, systems thinking is contained in more slowly evolving systems and contains faster-evolving systems. As some ways of systems thinking become 'classic' or conventional wisdom, they move up into the slower containing scales through a 'remember' connection. Newer situations or ways of systems thinking that require development and testing flow through the 'revolt' connection into the contained scales for more intense inquiry.

If systems thinking is itself a living system, the cycles within a single scale and multiple scales will learn with the environment and coevolve with other ways of thinking. Since the cycle of vigorous inquiry in the 1970s and 1980s, some significant new domains where systems thinking could make a contribution are as follows: (i) in the shift from industrial systems towards service systems; and (ii) in the shift from the Holocene to the Anthropocene.

Social Systems Thinking Rethought with Service Systems Thinking Draws in Man-made Infrastructures Ripe for Regeneration

Social systems thinking had traditionally focused on human organization, as the relations between and amongst individuals and institutions. The rise of the service systems thinking (Spohrer *et al.*, 2013) resurfaces systems thinking concepts on the cocreation of value and the coproduction of outcomes, with human technologies now omnipresent in advanced economies.

Human civilization is served by systems in technical, organizational and sociopolitical forms. A categorization of service systems that could be appreciated through primary and secondary school illustrates how core they are to our lives.

- Systems that *move, store, harvest and process* include transportation, water and waste management, food and global supply chains, energy and energy grids and ICT infrastructure.
- Systems that *enable healthy, wealthy and wise people* include building and construction, banking and finance, retail and hospitality, health care and education (including universities).
- Systems that *govern* include cities, regions and states, and nations (Spohrer and Maglio, 2010).

The most concrete of these service systems could be the focus of curriculum at kindergarten and early grades. The more abstract service systems would be better covered later in high school. More formally,

> A service system can be defined as a dynamic configuration of resources (people, technology, organisations and shared information) that creates and delivers value between the

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provider and the customer through service (IfM, IBM, 2008).

The study of service systems is developing science that transcends disciplinary boundaries. They are understood as complex systems where both human and nonhuman resources can be combined into collections in which interactions occur in nonlinear ways.

As a proportion of the advanced economy, the industrial economy of tangible products has been in decline for some years, and information services have been rising (Apte *et al.*, 2007). Furthermore, although the manufacturing and service sectors still employ the largest percentage of the workforce, the creative sector generates a much higher percentage of wealth (Florida, 2002). This new perspective of service systems thinking does not follow the traditional divisions between human systems and the man-made artificial (or artefactual) systems (Simon, 1996) that define the way of life in a civilization of developed regions and nations.

Our world has been described as a $54 trillion system of systems (IBM, 2010). In our modern civilization, the largest systems are infrastructure at $22.54 trillion, leisure–recreation–clothing at $7.80 trillion, transportation at $6.95 trillion, government and safety at $5.21 trillion and food at $4.89 trillion. This system of systems is complex, dynamic and interconnected. Critics describe many of these systems as either inefficient or dysfunctional. Improvement in the $54 trillion system of systems is seen as a $4 billion challenge. The inefficiency in these systems has been mapped on the dimensions of both potential for improvement and total economic value. Healthcare systems present the leading opportunity for improvement. Next are educational systems and government and safety systems. Building and transport infrastructure systems come next, with the largest footprint in absolute value. These systems are service systems that require change in both human subsystems and man-made technological subsystems.

Can we apply the learning from one type of service system to another type of service system? Does a healthcare system have anything to learn from an educational system, or vice versa? Does a government and safety system have anything to learn from a building and transport infrastructure systems, or vice versa? A reductive approach would see each service system as distinct. A systems approach to service systems recognizes that these service systems coevolve as interconnected, and successful improvements in one subsystem might have relevance in another.

Ecological Thinking Rethought with Regime Shift Thinking Draws in Sustainable Development in the Anthropocene

Ecological systems thinking has traditionally focused more on natural systems, e.g. landscapes and watersheds. Socio-ecological systems thinking extends resilience thinking with 'knowledge and understanding of ecosystem dynamics, how to navigate it through management practices, institutions, organizations and social networks and how they relate to drivers of change' (Folke, 2006). Ecologists have warned, for some decades, that human civilization should modify its ways to lessen the impact of our actions on ecosystems. With inaction and stalling having been exhibited as a common response, can ecosystems recover from the damage, or are we too late?

For the past 10 000 years, human civilization has enjoyed the benefits of temperate climates. After the last glacial cycle of $\delta^{18}O$, migrating hunter-gatherers settled down in the early Holocene with the advent of agriculture. Relatively predictable weather cycles have provided steady sources of food, with development from the ancient Greek and Roman empires to our current global society. Recent patterns in climate change have led to a scientific consensus that the days of predictable and temperate climates are ending.

A community of leading ecologists has conducted research on the 'safe operating space for nine planetary systems' (Rockström *et al.*, 2009a). This had led to the development of a list of nine earth system processes, as a consensus of the planetary boundaries. The boundaries in three earth systems processes have already been exceeded, that is, the following: (i) rate of biodiversity loss; (ii) climate change; and (iii) human interference with the nitrogen cycle (Rockström

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et al., 2009b). The development of the planetary boundaries framework is a major step forward in drawing attention to the socio-ecological system challenges, rather than a completed area of research. Some of the nine earth system processes have been tentatively defined, and spatial variability in impacts and feedback mechanisms are a question. The interactions between earth system processes are unclear. In addition, making progress on planetary boundaries transcends local and global scales of governance, so responsibility, leadership and coordination towards action require work.

The definition of ecosystem resilience differs from that for engineering resilience. Engineering resilience is 'a measure of the rate at which a system approaches steady state after a perturbation, that is, the speed of return to equilibrium'. Ecosystem resilience is defined as 'the capacity of a system to absorb disturbance and reorganize while undergoing change to retain essentially the same function, structure, identity and feedbacks' (Folke *et al.*, 2004). With an ecosystem nested between dynamic systems at different scales in a panarchy, an ecosystem might either recover to its prior state before a disturbance or shift into an entirely different regime of ecological systems and services. Research into regime shifts has been conducted in terrestrial and aquatic ecosystems. Ongoing research into regime shifts in the development socio-ecological systems continues.

The emergence of service systems science and regime shifts from the Holocene to the Anthropocene demonstrates that the scientific communities are responding to changes in the world. For systems thinking, changes in the nature of science should also be recognized.

Section 3 has taken the perspective that the world in which systems thinking engages has changed. Section 4 considers how systems thinking, as a system of ideas, might be evolving at this time.

EPISTEME AND TECHNE → PHRONESIS FOR THE LIVING AND NONLIVING

Is systems thinking itself changing? Changes within the field of systems thinking are concurrently evolutionary and revolutionary. Examining revolutionary changes may be more clearly seen by moving up the knowledge ladder from science to philosophy.

Ackoff and Churchman, in 1947, attempted to create an 'Institute of Experimental Method that was intended to conduct interdisciplinary research and problem solving where societies were involved' at the University of Pennsylvania. They were encouraged by the president of the university, who then retired because of illness. Their proposal was rejected by the new president. Ackoff moved to Wayne State University and started an Institute of Applied Philosophy (Ackoff, 2010, 98–99). This positioning on applied philosophy led to the advent of operations research and then a major branch of the domain recognized as systems thinking today.

Revolutionary systems thinkers arguing for transformation of the shared field of systems thinking could suggest that inquiries into philosophy are due.

Systems thinking deals with both living and nonliving systems. Advances in philosophy in the 21st century have included a 'practice turn' in which phenomenology takes a more prominent position (Schatzki *et al.*, 2001). The design of systems thinking, as an inquiring system, should embrace the opportunity to 'sweep in' new knowledge to progress the field (Churchman, 1971).

Thinking about Thinking Revisits Philosophies on Which Systems and Sciences Are Based

Criticisms of the dominant philosophy of science in the late 20th century and early 21st century are not new news. Stephen Toulmin described 'high science' as derived from two assumptions: (i) *episteme*, as authentic knowledge that is universal, general and timeless, elevated as a Platonic dream above humbler, detailed deductions; and (ii) *episteme* as axiomatic systems to organize knowledge and experience by scientists from René Descartes to Sir Isaac Newton. The geometric model of scientific theory linked to maxims, including the following: (i) the kinds of experiments and observations that are acceptable in a science; (ii) the objective detached posture of the scientist towards his objects of study; and (iii) the inferior status of 'practical' knowledge, as a secondary (applied) mode of understanding (Toulmin, 1996, 206–207).

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For Aristotle, the Platonic ideal of an episteme as the ultimate form of knowledge was misguided. Techne and phronesis should also be recognized, with phronesis as the most important, with no single discipline being the 'Master Science' (Toulmin, 1996). As we look towards challenges such as the rise of service systems and the Anthropocene in the 21st century, man-made technologies rise in importance both in practice and in theory. The perspective of ancient Greeks can be updated with a 20th century philosophy based in phenomenology. Surprisingly, Heidegger saw technology as a theoretical, rather than practical, affair.

> Technology is not practical directly, but only indirectly: by disclosing to us what constitutes beings, it provides us with a guideline that governs all our relations to beings, including our practical relations. It is in virtue of the truth disclosed in technology, i.e., in virtue of its theoretical significance, that technology is practical. Technology can do things only on account of what it sees, and what it sees is that which makes a being be a being at all (Rojcewicz, 2006, 56–57).

In human beings, the unchangeableness of episteme is a challenge. Whereas physical things cannot know themselves, a human being learns as he or she is able to disclose more of the world to himself or herself, with ontology as genuine knowledge, *episteme*, and *techne*, the knowledge of the changeable (Rojcewicz, 2006).

Although systems thinkers may collectively espouse to share a body of knowledge, a claim of perfect knowledge of the system of ideas in the mind of another person would generally be considered puffery. An image of a system of ideas (Boulding, 1961) has to be disclosed from one individual to another. Lived experiences do not transfer easily and cannot be expressed as changeless.

The Tradition of 'Know Why' and 'Know How' in Systems Thinking Should Be Complemented by Better 'Know When, Know Where, Know Whom'

The three intellectual virtues in philosophy are summarized in Table 4 with translations/interpretations, types of virtue, nature and pursuits. Colloquial descriptions and orientations are provided: (i) episteme is 'know why', oriented towards research; (ii) techne is 'know how'—particularly in a collective sense of methods oriented towards productions; and (iii) phronesis is 'know when, know where, know whom' with an orientation towards action.

A more detailed exposition on episteme, techne and phronesis as listed in Table 4 is provided by Bent Flyvbjerg:

> *Episteme* concerns universals and the production of knowledge that is invariable in time and space and achieved with the aid of analytical rationality. *Episteme* corresponds to the modern scientific ideal as expressed in

Table 4 Episteme, techne and phronesis as primary intellectual virtues

Primary intellectual virtue	Episteme	Techne	Phronesis
Translation/interpretation	Science (viz. epistemology)	Craft (viz. technique)	Prudence and common sense
Type of virtue	Analytic scientific knowledge	Technical knowledge	Practical ethics
Orientation	Research	Production	Action
Nature	Universal Invariable (in time and space) Context independent	Pragmatic Variable (in time and space) Context dependent	Pragmatic Variable (in time and space) Context dependent
Pursuits	Uncovering universal truths	Instrumental rationality towards a conscious goal	Values in practice based on judgement and experience
Colloquial description	Know why	Know how	Know when, know where and know whom

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> natural science. In Socrates and Plato, and subsequently in the Enlightenment tradition, this scientific ideal became dominant. [....]
>
> Whereas *episteme* resembles our ideal modern scientific project, *techne* and *phronesis* denote two contrasting roles of intellectual work. Techne can be translated into English as 'art' in the sense of 'craft'; a craftsperson is also an artisan. For Aristotle, both *techne* and *phronesis* are connected with the concept of truth, as is *episteme*. [....]
>
> *Techne* is … craft and art, and as an activity it is concrete, variable, and context-dependent. The objective of *techne* is application of technical knowledge and skills according to a pragmatic instrumental rationality, what Foucault calls 'a practical rationality governed by a conscious goal' (Foucault 1984: 255). […]
>
> Whereas episteme concerns theoretical know why and techne denotes technical *know how*, phronesis emphasizes practical knowledge and practical ethics. *Phronesis* is often translated as 'prudence' or 'practical common sense'. [....] Phronesis is a sense or a tacit skill for doing the ethically practical rather than a kind of science (Flyvbjerg, 2006, 371).

Science in the age of the Enlightenment—which is at the foundation of science in the west today—emphasized episteme and techne. However, the primacy of phronesis in Aristotle's philosophy has required reiteration.

> In Aristotle's words, phronesis is an intellectual virtue that is 'reasoned, and capable of action with regard to things that are good or bad for man' (Aristotle, *The Nicomachean Ethics*…). Phronesis concerns values and goes beyond analytical, scientific knowledge (episteme) and technical knowledge or know-how (techne), and it involves judgements and decisions made in the manner of a virtuoso social actor. [....]
>
> Aristotle was explicit in his regard of phronesis as the most important of the three intellectual virtues: episteme, techne and phronesis. Phronesis is most important because it is that activity by which instrumental rationality is balanced by value rationality, to use the terms of German sociologist Max Weber and because, according to Aristotle and Weber, such balancing is crucial to the viability of any organization, from the family to the state (Flyvbjerg, 2006, 370).

In a common-sense view of the world, applying 'know why' (episteme) and/or 'know how' (techne) in the wrong place, wrong time and/or with the wrong people signals immaturity in practice. Applying 'know when, know where, know whom' appropriately demonstrates an appreciation of the situation at hand, a possible implicit weighing of values and the setting for an appreciative system.

Episteme, Techne and Phronesis Can Map to Systems Theory, Systems Methods and Systems Practice

One breakdown of systems thinking is a three-way categorization into the following: (i) systems theory; (ii) systems methods; and (iii) systems practice. This is not the only way to analyse systems thinking, yet it may be useful in an alignment with the following: (i) episteme; (ii) techne; and (iii) phronesis. A variety of schools of thought and seminal references are included in these categories, to make complements and gaps clearer to see. This list is intended as indicative, rather than exhaustive, so other systems thinkers might organize the details in a different way. In addition, because theory and methods and practice can all influence each other, there are some ties between the domains that may not be readily apparent.

Systems theory, as episteme, includes the following:

- living systems theory (Miller, 1978);
- open systems theory (Merrelyn Emery, 2000);
- the viable systems model (Beer, 1972; Espejo and Reyes, 2011);
- inquiring systems (Churchman, 1971; Mitroff and Linstone, 1993);
- critical systems thinking (Flood and Romm, 1996);

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- hierarchy theory (O'Neill *et al.*, 1986; Ahl and Allen, 1996); and
- panarchy and ecological resilience (Gunderson and Holling, 2002).

Systems methods, as techne, includes the following:

- systems dynamics (Morecroft and Sterman, 2000);
- soft systems methodology (Checkland and Poulter, 2010);
- interactive planning (Ackoff, 1981);
- action research (Reason and Bradbury, 2001);
- strategic assumption surfacing and testing (Mason and Mitroff, 1981);
- search conference (M. Emery, 1996); and
- structured dialogic design (Flanagan and Christakis, 2010).

Systems practice, as phronesis, includes the following:

- appreciative systems (Vickers, 1968; Checkland, 2005);
- evolutionary development (Laszlo and Laszlo, 2004);
- language action perspective (Denning and Dunham, 2006; Winograd, 2006); and
- systems intelligence (Hämäläinen and Saarinen, 2007).

Individuals come to systems thinking as a way of filling in gaps within their disciplines and/or in their training. Systems theory as 'know why' may be attractive to engineers or business leaders seeking better ways to model or implement designs. Systems methods, as techne, may increase the productivity of organization developers and community facilitators to improve coherency in a group towards remediation or innovation. Systems practice, as phronesis, may be attractive to individuals or teams seeking personal development or improved performance at more holistic levels. Advances in philosophy related to theory of practice and communities of practice present opportunities to influence a rethinking of systems practice.

Theory of practice, as developed by Pierre Bourdieu, revolutionized social theory (i.e. the philosophy underlying sociology). Three concepts are at the heart of Bourdieu's work: habitus, capital and field. *Habitus* sees social life as a mutually constituting interaction of structures, dispositions and actions that shape and are shaped by social practice. Species of *capital* include social capital, cultural capital and economic capital, which may be exercised as forms of power to exercise control over one's own future and that of others. *Fields* are semi-autonomous, multi-dimensional spaces where agents take positions in an accumulation of history with a logic of action and recognition of its own forms of capital (Postone *et al.*, 1993, 3–6). Future development of research into systems practice could benefit by an appreciation of the reproduction of social practices, as feedback loops that resist change.

Communities of practice emerged from research into social learning through Etienne Wenger at the Institute for Research into Learning. With Bourdieu as one of the foundation for the models, learning is expressed in both the contexts of individuals and collectives in a framework that includes the following:(i) meaning; (ii) practice; (iii) community; and (iv) identity. *Meaning* is a way of talking about the ability of individuals and collectives to experience the world as meaningful. *Practice* is 'a way of talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action'. *Community* is 'a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence'. *Identity* is 'a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities'. The four elements are deeply interconnected and mutually defining. (Wenger, 1999, 4–5).

Prior systems research into praxeology (Gasparski *et al.*, 1996) may be complementary to the more popular work on theory of practice and communities of practice. Systems thinkers have an opportunity to move engagement with a new generation of thinkers by appreciating their traditions and building new bridges.

At the same time, the domains of knowledge in systems thinking (and the systems sciences) have not been standing still. Critics of mainstream science often centre on a philosophy of logical positivism. In a broader view, Stuart Umpleby described four models used in the systems sciences: (i) linear causality; (ii) circular causality;

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(iii) complexity theory; and (iv) reflexivity theory. *Linear causality* is the way that most science has been carried out, with hypotheses that can be falsified and propositions that can be assigned a level of statistical significance. *Circular causality* is well understood in regulatory processes in cybernetics, modelled with causal influence diagrams and system dynamics models. *Complexity theory*, with the Santa Fe Institute as a leading centre for research, has been based primarily on computer simulation, with the creation of a new variety and selection of an appropriate variety. *Reflexivity theory* involves self-reference, paradox and inconsistencies (Umpleby, 2007, 1).

Second-order cybernetics dates back to the 1970s. Reflexivity has made significant inroads into social theories in cultural anthropology (e.g. Pierre Bourdieu, with *An Invitation to Reflexive Sociology*) and in understanding the workings of financial markets (e.g. George Soros, with a *General Theory of Reflexivity*).

Driven by frustrations in *Science I* where the paradigm of physics that all things should be explainable through rules, laws and algorithms, the opportunity for *Science II* has been presented (Umpleby *et al*., 2012). A new perspective on science, as a rigorous expansion of common sense, was proposed. The wisdom of cybernetics posed the following challenges: (i) adding the observer to science; (ii) adding feed-forward reasoning; and (iii) adding will and/or purpose to science, which is being investigated. This requires a new epistemology and ontology to deal with looming natural, demographic and social singularities.

Some ways of thinking in domains regarded as outside the systems movement may not have been recognized as part of systems thinking yet could be highly compatible. With some effort from both sides, bridges could be built for mutual benefit. Many of these advances have been associated with interests in (human) action, practice and (social) learning.

Paths to Rethink Systems Thinking Are Domain Dependent, with Induction for Episteme, Abduction for Techne and Deduction for Phronesis

With systems thinking now having been categorized by foundational philosophies, the ways in which systems thinking may be rethought will not be uniform.

Presuming an interest in rounding out a knowledge of systems thinking, each individual comes from a different background of experiences. We each take different courses in secondary and post-secondary education, and then avocations and passions bring us along different paths. As an exercise, let us think through three cases in which systems thinking might be developed from different staring points. Table 5 outlines three

Table 5 Plans to develop systems thinking

Episteme (e.g. theoretical science and codified principles)	Techne (e.g. methods and techniques and collaboration)	Phronesis (e.g. hands-on experience and values in practice)	Proposed path for learning and coevolving	Case domains
√ (strong)	√ (strong)	☐ (weak)	Deduction: *when*, *where* and *for whom* are systems promising and/or salient?	Extending systems principles to new domains
☐ (weak)	√ (strong)	√ (strong)	Induction: *why* are the natures or behaviours of systems similar or dissimilar?	Developing new systems theories, for example, service systems
√ (strong)	☐ (weak)	√ (strong)	Abduction: *how* are future systems to be developed or improved over current systems?	Enabling collective action on systemic challenges, for example, the Anthropocene

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paths where plans to develop systems thinking might be considered.

Let us assume that a category of systems thinking is strong in two intellectual virtues, but weak in the third.

Path (a), strong on episteme and techne, weak on phronesis:

> In conditions where episteme is strong, techne is strong and phronesis is weak, systems thinking is evident in books but light in practice. In a deductive approach, challenges are sought for when, where and for whom a systems approach is promising and/or salient. Extending systems principles to additional domains—for new applications or for new social groups—requires practical ethics to make a difference in the world.

Path (b), weak on episteme, strong on techne and phronesis:

> In conditions where techne and phronesis are strong, but episteme is weak, a programme of theory building could be productive. Knowing how to manage a project (i.e. techne) with a large degree of hands-on experience (i.e. phronesis) provides an empirical foundation for the development of theories. An inductive path of learning could include mentoring by a master who can develop insight into how prior experiences are (or are not) similar. Such regimens of abstraction can deepen expertise, separating the novice who still needs the textbook from the guru who writes them. This could be the case for the emerging science of service systems, where there's a wealth of variety, but little theory developed.

Path (c), strong on episteme, weak on techne and strong on phronesis:

> In conditions where episteme and phronesis are strong and techne is weak, the direction and motive for change may be strong, but the roadmap to success is hit or miss. An abductive path of learning could release a systemic redesign from reformation to transformation. Dealing with the anthropocene is such a challenge, where emergent local action may not result in global change.

Section 4 has suggested ways in which systems thinking might learn and coevolve. Change from the perspective of both the system and its environment closes out this article in Section 5.

RETHINKING SYSTEMS THINKING CAN BE APPROACHED REACTIVELY, INACTIVELY, PREACTIVELY OR INTERACTIVELY

Will systems thinking be rethought? Following Ackoff's descriptions of orientations towards change, systems thinkers may be inactive, reactive, preactive or interactive.

> Inactivists are satisfied with the way things are and the way they are going. Hence they believe that any intervention is unlikely to improve them and it is very likely to make them worse. [….] They seek stability and survival. [….] Inactivists believe that most apparent social and environmental changes are either illusory, superficial or temporary. [….]
>
> Reactivists prefer a previous state to the one they are in now and they believe things are going from bad to worse. Hence they not only resist change but they try to unmake previous changes and return to where they once were. [….] Reactivists are moved more by their hates than their loves. Their orientation is remedial, not aspirational. They try to avoid the undesirable rather than attain the desirable. [….] Because technological change is so conspicuous and because the past has always had less technology than the present, technology is the reactivists' principal scapegoat for whatever ills they perceive. [….] Reactivists dislike complexity and try to avoid dealing with it. [….] Unlike inactivitists, reactivists do not ride with the tide; they try to swim back to a familiar shore. [….]
>
> Preactivists are not willing to settle for things as they are or once were. They believe that the future will be better than the present or the past, how much better depends on how well they get ready for it. Thus, they attempt to *predict* and *prepare*. They want more than survival, they want to grow—to become better, larger, more affluent, more powerful, more many things. [….] Preactivists seek change *within* the system, but not change *of* the system or its environment.

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> They are reformers, not revolutionaries. [….] Preactive planners take their function to consist of producing plans and presenting them to those empowered to act, but no involvement in implementing approved plans. [….]
>
> Interactivists are not willing to settle for the current state of their affairs or the way they are going, and they are not willing to return to the past. They want to design a desirable future and invent ways of bringing it about. [….] They try to *prevent*, not merely prepare, for, threats, and to *create*, not merely exploit, opportunities. [….] Interactivists are radicals; they try to change the foundations as well as the superstructure of society and its institutions and organizations. They desire neither to resist, ride with nor ride ahead of the tide; they try to redirect it (Ackoff, 1997).

A community of systems thinkers that thinks that the field needs to be rethought will be challenged by inactivitists and reactivists. Preactivists may support rethinking systems thinking, but the interactivists are the individuals who will drive change.

Although rethinking systems thinking might add some new ideas to the more than half century of work that has already been produced, the diversity and scope of the field are already a challenge to novices entering the field. One way to approach innovation in systems thinking is not to look to what we can add, but what we can abandon.

> Innovation depends rather of what we might call 'organized abandonment'.To get at the new and better, you have to throw out the old, outworn, obsolete, no longer productive, as well as the mistakes, failure, and misdirections of efforts of the past.
>
> Think of the old medical saying: 'As long as the patient eliminates there is a chance. But once the bowels and the bladder stop, death does not take long'. (Drucker, 1992, 272)

To rethink systems thinking, we need to both embrace the advances from new research, methods and practices and also identify and expunge errors and misdirections that slow us down.

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