Scalability of Knowledge Transfer in Complex Systems of Emergent "living" Communities

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ABSTRACT

Communities are emergent, holistic living systems. Understanding the impact of social complex systems through spatial interactions via the lens of scalability requires the development of new methodological behavioural approaches. The evolution of social complex systems of cities and their regions can be investigated through the evolution of spatial structures. The clustering of entities within cities, regions and beyond presents behavioural elements for which methodological approaches need to be considered.

The emergent aspect of complex entities by their very nature requires an understanding that can embrace unpredictability through emergence. Qualitative methodological approaches can be holistic with the ability to embrace bottom up and top down methods for analysis. Social complex systems develop structures by connecting "like minded" behaviour through scalability. How "mobile" these interactions are, is a concept that can be understood via "inter-organizational" and "inter-structural" comparative approaches. How do we indeed convey this adequately or appropriately?

Just as a geographical area may contain characteristics that can help to support the formation of an emergent industry cluster, similar behaviours occur through emergent characteristics of complex systems that underpin the sustainability of an organization. The idea that complex systems have tacit structures, capable of displaying emergent behaviour, is not a common concept. These tacit structures can in turn, impact the structural sustainability of physical entities. More often than not, there is a focus on how these concepts of complex systems work, but the "why" questions depends upon scalability. Until recently, social complex adaptive systems were largely over looked due to the tacit nature of these network structures.

Keywords: Social and spatial scalability, living systems, unpredictability, social complex adaptive systems, emergent qualitative methodological approach.

1. INTRODUCTION

The concept of complex adaptive systems underpinning sustainability (across multiple themes) seems overwhelming when the behaviour of these interactive multiple systems are living and dynamic. The value of viewing key interactive points of dynamic systems, transactions or "states" via the lens of scalability, is an important concept to grasp when exploring behavioural elements and their impact of dynamic systems.

This paper aims to address the development and impact of emergent methodological approaches and models with a focus on the unpredictability of qualitative relationships and their behavioural elements. The work in this paper has been partly informed by the developmental analysis of the "group" or a "systems wide emergent phenomena". Within the group analysis there was a focus on the behavioural approach of a bottom up – top down view, resulting in various forms of "group clustering dynamics".

Understanding the concept of scalability is fundamental as a means for manoeuvring through and between systems levels regardless of their substance (physical or tacit). This concept has not as yet been expanded to such a degree as to be widely, or consciously recognized as a necessary behaviour required for emergence in geographical and geophysical spaces. The concept that structures such as societies, regions and connections beyond continuously ("scalable complex systems interoperability") interact on multiple scales, has not been fully appreciated or given the attention it requires. Understanding these movements engages a vast variety of perturbations that impact design for cities, regions and beyond. The basis for new methodological approaches needs to emerge, and needs to be adjustable during analysis and field work alike, including reflection for the evolving living system.

2. METHODOLOGICAL APPROACH – THE THEORY AUTOPOIESIS - EXTENDING MATURANA AND VARELA'S AUTOPOIESIS

Maturana and Varela [1] [3] [5] [2] proposed that living entities were distinguished from non-living by a recursive process of self-maintenance and self-production that they called autopoiesis, where systems with interacting components that self-distinguish themselves as entities from the surrounding spatial medium. Hall [8] [9] [11] [10] extends Maturana and Varela's ideas to provide the initial foundation for a generic realist theory of autopoiesis that can be applied to systems across several hierarchical levels of complexity.

Cyclically complex systems are constantly emerging [8] [9] [11] [13] [14] [15] in the physical world as a natural consequence of the entropic dissipation as energy (and can also be considered as potential of an entity) is transported by the medium from high potential sources to low potential sources [8] [9] [12]. Hall [11] [8] [9] notes that the sources and sinks have potential differences between them with interacting components, and these types of physical transport systems become cyclical and complex, involving the interactions of a range of different kinds of components [17] [18] [19] [22] [23] [24] [25] [26] [27] [28] [21].

As no generally accepted scientific definition of life has yet been agreed upon [8] [9] [11] [29] [30] [45] the approach taken in this work is that the six criteria given by Varela et al. [7] are to be used as the starting point for recognizing when any complex system should be considered to be living. As substantially paraphrased [9] [12] [14] from Varela et al. [7], the six properties a system must exhibit to be considered living, and therefore autopoietic, are:

1. Bounded (distinguishably demarcated from the environment)
2. Complex (separate and functionally different components Within the boundary)
3. Mechanistic (system dynamics driven by self-sustainably regulated fluxes or metabolic processes)
4. Self-differentiated (system demarcation intrinsically produced)
5. Self-producing (system intrinsically produces own components)
6. Autonomous (self-produced components are necessary and sufficient to produce the system).

Maturana [4] states that "...the physical boundaries of a living system... are realized by its components through their preferential interactions within the autopoietic network... as surfaces of thermodynamic cleavage [p. 30]".

Hall [8] [9] [11] argues that autopoiesis can emerge at different scales within and between organizational hierarchically complex systems. These systems can self-define levels of focus, and determine what constitutes the component subsystems and environmental super-systems. Autopoiesis was originally proposed to define life of cellular systems in an environment containing macromolecular components, where it evolves in a hierarchically complex world as a consequence of the fundamental laws of thermodynamics [6]. Hall [8] [9] argues, that the molecular level of autopoiesis may emerge at any level of an organization where (a) lower level components offer a sufficient variety of interactions to support cyclically dissipative dynamics and the emergence of control information; and (b) the higher level super-system or environment continues to offer a potential gradient able to fuel the continued existence of self-stabilized cyclical systems to provide the dissipation [8] [9] [11].

Karl Popper's [35] evolutionary epistemology with a theory of complex self-maintaining systems informs Maturana and Varela's [2] autopoiesis. The paradigm summarized here is based on autopoiesis, differs from Luhmann's [31] [32], in short, the work in this paper views autopoiesis as a spiral rather than a closed loop [44].

Popper grounded his evolutionary epistemology [35] [36] in a metaphysical ontology of three "worlds" or domains:

- World 1 ("W1") is external reality or everything that exists.
- World 2 ("W2") is the domain of cognition and embodied or "dispositional" knowledge. Polanyi's [33] [34] personal and tacit knowledge are encompassed within W2 [9].
- World 3 (W3) is where explicit or "objective" knowledge such as the logical contents of books, computer memories, heredity and other persistent products of cognition is found [35].

Popper [35] notes, the cycles are not exactly repeatable, because incremental additions of tested knowledge change the perceived problem states from one cycle to the next (living, dynamic behaviour). Nousala [13] (figure 2) describes the spiral action of autopoietic community behaviour as emergent with constraints and boundaries shaping the living process and ultimately the basis for possible sustainable entities through a series of "states". Figure 2 shows in detail a possible process in action that can interact with multiple processes as shown in figure 3.

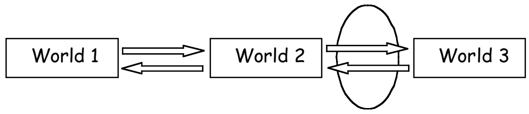

Figure 1. Modification of Popper's three worlds diagram to show cyclical movements.

The circle in figure 1 emphasizes cyclic exchanges between world 2 and world 3 as world 2 attempts to represent and interact with world 1 [13] [15].

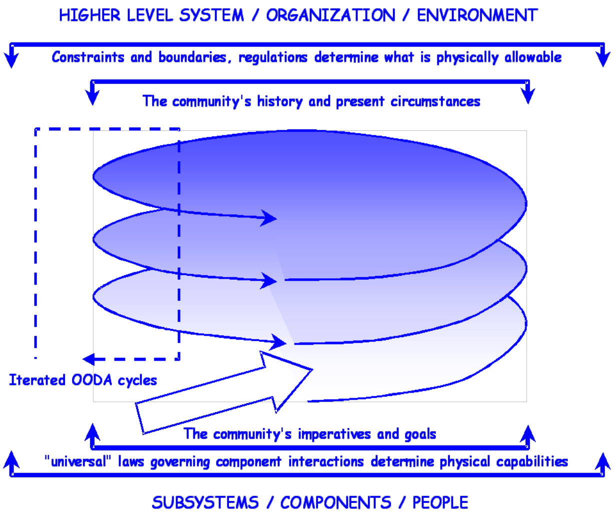

Figure 2. Emergence of an autopoietic community of practice. [13]

Figure 2 places Nousala's spiral knowledge exchange model in the complex systems hierarchy of an autopoietic organization (Figure 3). Dynamic activities of entities at the focal level within the triad are enabled by laws governing interactions of subsystems and constrained by conditions imposed by the super-system [37] [10]. Subsystems below the focal level determine what is possible for the system to do via initiating conditions and "universal" laws governing the interactions of subsystem components. Koestler introduces the concept of "holon(s)" to summarize stable subsystems as components in a broader complex system. [46] `The "environment" or super-system containing the holon as a component establishes situational boundary conditions to shape and constrain the holon to determine its emergence and development through history [12] [14].

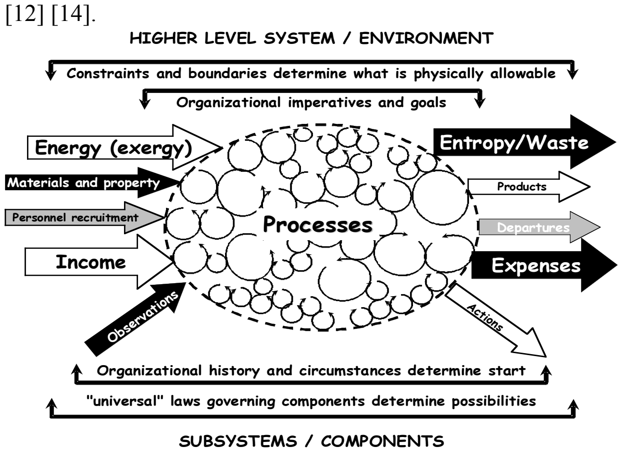

Figure 3. Structure of an autopoietic organization [10] [13] [16].

Figure 3 illustration shows some of the major functional subsystems that would be found in a autopoietic organization.

The processes evolving and emerging at differing rates need to be viewed holistically through a longitudinal approach.

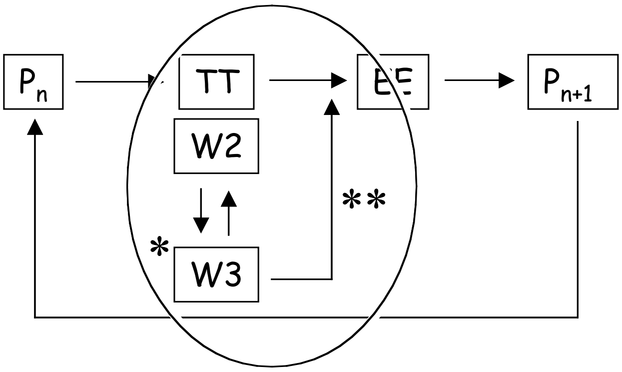

Figure 4 – Modification of Popper's tetradic schema and three worlds diagram [10].

Figure 4 represents a modification of Popper's combined tetradic schema and three worlds diagram shows the beginnings of the cyclical nature of tacit knowledge exchange. * The tentative solution is objectified as a tentative theory in W3. ** The tentative theory in W3 is subjected to critical analysis to eliminate errors. The circle emphasizes the area expanded in Figure 5.

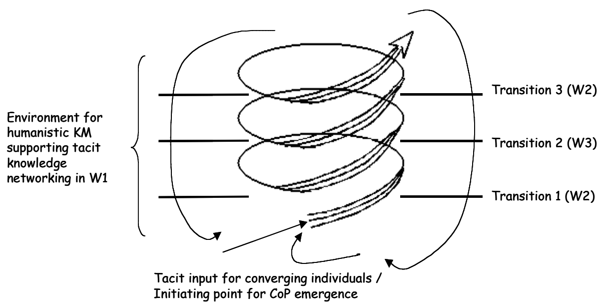

Figure 5. Nousala's [13] **spiral transition exchange model.**

In Figure 5, processes within the emerging form a communities of practice (CoP), cyclically transform knowledge between tacit forms in the [35] W2 and explicit forms in W3. The vertical dimension shows time and practice = evolving to the next level of knowledge. Transition 1: initiating point for tacit knowledge exchange ("TKE"). Transition 2: criticism of articulated tentative solutions. Transition 3: personal understanding of the problem solution for the cycle, with adjustments to constraints to iterate the process. As Popper [35] notes, the cycles are not exactly repeatable, because incremental additions of tested knowledge change the perceived problem states from one cycle to the next.

"Time and practice" are required between each transition. Time is needed for the community to actually articulate knowledge into W3 for transfer and back into personal W2 to put the knowledge into practice (i.e., to test it). Each of the transition levels, 1, 2 and 3, represent a tacit exchange or evolutionary increment through time in the quality of knowledge available to the CoP.

Organizations are non-static complex systems that have evolved over time. This sentiment is shared by two economists, Nelson and Winter [20] who argue that they prefer approaching organizational function with a more "appreciative version" as opposed to the "formal orthodoxy, displayed in logically structured theorizing…". They say that they use the term "evolutionary theory" as it signifies a borrowing of basic ideas from biology, which is centric to their scheme "the idea of economic natural selection" [42] [p.8].

3. FROM THEORY TO PRACTICE

Utilizing observations of a year-long project (initiated by a department of a European national government) the consortium involved (consisting of a multi-sectorial, multi-disciplinary group) provided a rich basis from which to participate as an embedded researcher. Through the collective experiences of the consortium members, an understanding was gained of how and what development was important. The experiences also showed why tacit knowledge networks "moved" to impact behaviour (in the way it did) between multiple layers of relationships and activities (highlighting which activities were considered key along the way).

Interaction occurred at levels that were at first between key attractors (individuals) or "human attractors", then between activities, finally building up into multiple "stands" of interactions, forming key transition points (at first a few, then many of various impact and strength). These strands moved between "non physical states" moving together as small groups, clustering around issues of commonality.

As with individuals and teams within projects, industry clusters can coalesce organizations (including whole regions) to form complex systems. Action research provided a practical approach to observe and investigate the consortium activities. Initially, the experience of utilizing the theory (as it is described) for fieldwork seemed counter intuitive, due to the obvious choice of starting with the tracking of known activities (these were occurring and acting simultaneously through a multitude of scales).

Tracking known activities was an approach that could not in and of itself, produce the desired understanding of the "whole systems view". The theory required a "translation" for use in the field beginning with the bottom-up, top-down approach, which assisted with the "experiential understanding" or "know how", creating a "systems behavioural approach".

The systems behavioural approach provided the basis for a "holistic instance" from which to experience viewing the levels and scales in relation to the whole system (a holistic instance). The holistic instance produced a simultaneous impact that allowed for an experiential observation and understanding of a scalable, holistic entity, in action, viewed through the lens of scalability.

There is a lack of critical understanding regarding the significant practical impact for creating effective industry based sustainable systems. The conscious development of sustainable systems would impact various societal groups such as small, mid to large organizations, cities, regions and countries. Subsequently, the development of successful industry clustering potentially combined local, regional and national elements on all levels. The organizations involved in this work were a very diversified collective [16].

The research focused on two different aspects:
a. short term investigation into common issues and possible solutions.
b. long term, how this diverse group can form the basis of an industry platform for continuous behaviour on several levels.

By initially focusing on the consortium issues and approaches, it was possible to initiate the beginnings of an emergent process from "grass roots", to facilitate identification and development of a wider collective methodological outline. Investigation and documentation of this methodology contributed to new concepts "in practice" towards methods, applications and socio-technical approaches.

4. THE SIGNIFCANT PROBLEMS OF SUCCESSFUL INDUSTRY CLUSTERING WITHIN REGIONS

Improvements via long-term bottom up approaches (requires longitudinal thinking for implementation time lines) created efficiencies that supported and under pinned sustainability (economically, socially) for the organizations involved which they could (in the long term) translate into their immediate urban environments.

Longitudinal approaches from policy to practice rarely have the opportunity to occur in a sustainable manner. An alternative approach would be to provide an innovative method for visual horizontal analysis of knowledge networks, in contrast to the traditional siloed, hierarchical methods for information and data analysis. Rittel and Webber's [38] formulation of wicked problems are perhaps best considered in the context of social policy planning. Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly. It is not possible to "pilot" policy implementation, like wise it is not really possible to pilot clusters or impacts on territories or regions.

A practical example of policy implementation issues can be seen through investigations into industries and their supply chains in Australia, Asia and internationally. Whole clusters and industries have been built upon a small, medium enterprise (SME) base, but reliance on traditional top down approaches used for investigation into strategies and insights for transforming SMEs and the like into more innovative entities, have been less than successful. This is mainly due to the difficulty for SMEs to find resources to be noted on an individual level. Therefore, many resort to seeking (within their supply chains) access for collaborative approaches to tackle industry wide issues, for which they may or may not be equipped for [41].

The Australian Review of the National Innovation System Report, Recommendation 3.3 of the Review [42], highlighted the crucial importance of new connections and clusters for the competitive advantage of firms in knowledge-based economies. The report emphasized the importance of collaboration amongst SMEs and with research providers; in fact, the term "collaboration" appears repeatedly in the report.

Collaborative approaches have now been recognized [39] [40] as desirable when developing methodologies for SME collaboration and industry clustering. These ideas of collaborative approaches for SMEs are now more widely attempted and understood.

These collaborative approaches have also been attributed to supporting SME activity beyond the SMEs' themselves. For example, these interactions would include exchanges between entities from other sectors and areas of expertise, individuals, other ad-hoc clusters (that could behave more like CoI groups) and more formal groups (CoPs) [47][48]. These different combinations of expertise or "poly-disciplinary" exchanges enhanced the current skillset and created new ones.

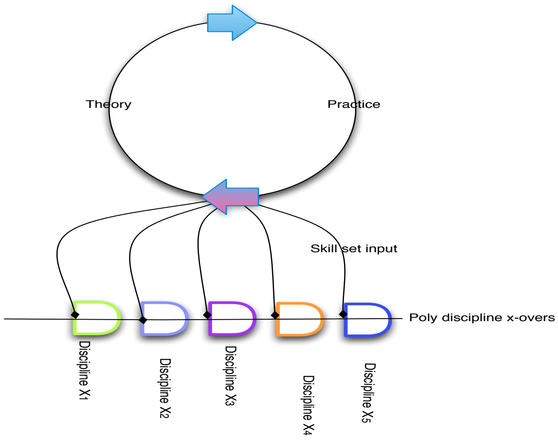

Figure 6. Poly-discipline, an over arching term to express all types of exchanges between disciples, to support general discussions [47] [48].

In Figure 6, the term "poly-discipline" was first used at the Kororoit Institute, International symposium and workshop, Living Spaces for Change: Socio-technical Knowledge of Cities and Regions, March 2012, North Melbourne, Australia. This poly-disciplinary discussion was published at ECCS 2012, European Conference on Complexity Systems, Brussels 2-7 September 2012.

These dynamic interactions were seen as useful, since there was the possibility for an entity to exchange in a more horizontal fashion and make new links and connections beyond the "usual" scope of the SME and its usual network base. As these new connections were formed they were capable of adopting and learning new methods and elements for accessing different or required operational levels. These levels were capable of supporting the SMEs or entities in new dynamic, longer-term ways.

5. THE IMPORTANCE OF KNOWLEDGE LEVELS AND THEIR LINKS TO SCALES WITHIN SYSTEMS

Nousala [13] discuss Nelson and Winter's thinking [20] regarding the fragility or wellbeing of the long term viability of an organization or in other words, its sustainability, within competitive environments highlighted by Nelson and Winter's [20] [p.10] description of the inadequacy of the "theoretical foundation that orthodox micro-economics provides for macro-economics".

Nelson and Winter [20] further discuss the general expression of the current theory, which is unable to adequately deal with uncertainty of large corporations and their organizational complexity. Tacit protocols are a part of the development of knowledge networks that bind communities together through various stages of development, from the first steps of integration and possible eventual dis-integration [13]. Both unconscious competence and conscious competence are present and relevant elements of tacit protocols, which trigger the clustering of tacit knowledge links into coalescing, and finally focusing into "commonalities" of knowledge levels [13].

These knowledge levels become evident or even more so when consciously sort. All this may seem obvious, however, tacit protocols have not been considered or seen as fundamental in regards to communities of practice (CoP) in complex, hierarchical or dispersed groups. Tacit protocols were also found to have levels within levels. For every gathering under a unified cause, i.e., CoPs, communities of interest (CoIs) or expert communities of interest (ECoIs) tacit protocols were active [13].

The basis for the awareness of scales and working within selected scales was a question posed by the consortium. This question of how and why scales are important or appropriate may be one of the observance of natural formations of clustering of knowledge links as transitional "markers" for links that highlight important "current relevant scales".

6. CONCLUSION

Using developmental snapshots to observe outcomes as a series of "states" within the consortium (several large organizations, inter company, government bodies and forums) highlighted the importance of human attractor/s (may also be an outside facilitator/s). Similarly, this corresponds to what had been observed during the formation of SMEs around a charismatic entrepreneur serving as the personal attractor. SMEs themselves also served as attractors for industry clustering within regions.

Key outcomes were observed from the consortium experiences through the examination and analysis and interactions within and between group dynamics and levels. Key elements became evident, such as the identification of tacit protocols. Tacit protocols are important, and exist in a "non form", and mirror explicit actions and structures through a series of sequences and instances. Tacit protocols are important in relation to how they create links into the way in which tacit context influences or is influenced by the tacit content, depending on the level of knowledge interaction. These knowledge levels interact with and correspond to explicit content and context. In this way, the tacit can mirror the explicit structures, albeit in a different time sequence.

This type of understanding of knowledge levels through tacit protocols may be achieved through various ways, for example physical interaction by working in the same space, by combining inter-relating tacit and explicit work through each other' networks, data bases, codified reports etc. The tacit and explicit content and context that occur simultaneously are guided by focusing on both tacit and explicit protocol interaction. Therefore, protocol of the tacit variety can be applied individually and collectively when access is made via one point connecting to or tapping into a wider, more encompassing meta-cognitive knowledge system [13].

Understanding the impact of knowledge levels and their links to scalability and relevant behavior was a core element to work discussed within this paper. Longitudinal movement between scales did not always focus on an increased size or range of an entity and its activities (which typically favoured economic outcomes). The impact of knowledge levels linkages with differing scales could also influence the social sustainable success or ultimate failure of short or longer-term ventures, including the clustering of entities and beyond (depending on the health of the initial linkages) [49].

This research area is a significant, emergent field of social complex adaptive systems (socio-technical) focusing on the implementation of processes involved in this multi-disciplinary field. The skill set required is considerable due to the embedded practice approach when looking organizational systems, their networks and beyond.

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