System Dynamics and Organization Dynamics : state of the art and issues

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Abstract:
This paper explores the potentialities of cross fertilization between system dynamics and organization dynamics, and proposes new ways for joint studies.

Key words:
general systemtheory, complexity, organization dynamics, emergence.

System dynamics and organization dynamics evolve as two parallel research fields without any contact. This paper explores the possibilities for establishing cross-fertilization between these two fields.

1. General system theory and system complexity

K. Boulding (1956) outlined in a famous article *"two approaches to the organization of general system theory"*. In the first one, he stated *"a phenomenon of almost universal significance for all discipline is that of the interaction of an "individual" of some kind with its environment. Every discipline studies some kind of "individual"- electron, atom, molecule, crystal, virus, cell, plant, animal, man, family, tribe, state, church, firm, corporation, university, and so on."* For the second approach he proposed : *"the arrangement of theoretical systems and constructs in a hierarchy of complexity, roughly corresponding to the complexity of the individuals of various empirical fields"* and he suggested a possible arrangement of nine levels of theoretical discourse. By doing this, the author introduced a new source of complexity we named (Liu, 1997) : the system complexity.

K. Boulding separated the levels by considering the static properties of each of them, not their dynamical ones. One reason for this, could be found in the difficulties to observe dynamic processes and in the European culture, to conceptualize them, for the thinking of this culture is dominated by the concept of Being (Parmenide, 1988), which is static.

2. Dynamic differences between system complexity levels

The dynamic features of the first two levels of system complexity are known quantitatively, while for the other levels beginning with the third one no significant quantitative studies are available, since no quantitative methods exist. The knowledge we have on their dynamics are qualitative and empirical. However, they are of significance, and contribute, as much as the static ones to the distinction between the system complexity levels, since :

a) all empirical individuals belonging to the same levels have the same dynamics. Different levels show differences in the nature and in the number of processes
b) a high level owns all the processes of all the lower levels. A higher level has more complex processes than a lower one
c) the dynamic processes are numerous and complex in the whole hierarchy of the system complexity levels

The main processes of each level are presented in table 1.

Table 1 : Main processes of the system complexity levels

System complexity level	Processes
8. Social	Emergence, culture invention, symbolism, technical instrumentation, norms, ethics, values, revolution
7. Human	Emergence, reproduction, embriogenesis, self conscious, learning, knowledge elaboration, emotions, motivation , psychological and intellectual mutations, death
6. Animal	Emergence, reproduction, mobility, teleological behaviour, self awareness, reactivity, death
5. Plant genetic societal	Emergence, reproduction, differenciation, integration, tropism, death
4. Cell	Emergence, homeostasis, self reproduction, self maintenance, life, death
3.Control mechanism cybernetic	Elaboration, information, replication, diffusion, transcription, destruction
2. Clockworks	Elaboration,motion, dissipation
1. Static strucure	Elaboration, obsolescence

3. Comparison between the dynamics of the system complexity levels.

3.1. Functional dynamics

We propose two classifications of the system dynamics within the hierarchy. The first one is based on the notion of functional dynamics, where we distinguish five classes based on five functions we can observe in the empirical individuals of the system complexity hierarchy.

a) The genesis dynamics : we include in this function the processes of fabrication, replication, mitosis, sexual reproduction, embriogenesis, emergence, constitution of social entities, all processes which bring into existence the diverse empirical individuals
b) The perpetuate dynamics : structuring, equilibrium, homeostasis, quest of identity are included in this category
c) The development dynamics : biological growth and adaptation, reaction, learning, targeted action
d) The transformation dynamics : the processes are biological mutation, psychological conversion, reframing (Bateson, 1971), social revolution
e) The destruction dynamics includes entropy, erosion, obsolescence, death, dissolution

Table 2 shows the existence of the functional dynamics with regard to the system complexity levels. Since the knowledge on dynamics are in progress in every science devoted to the study of the empirical individual of those levels, the results shown in table 2 may change in the future, nevertheless the conclusions we draw from it will hold, because they are not founded on results that are specific to one science, but come from the overall framework of the system complexity level hierarchy.

Table 2 : Existence of functional dynamics in system complexity levels

System complexity level	Genesis dynamics	Self-mqintenance dynamics	Development dynamics	Transforma-tion dynamics	Destruction dynamics
8. Social	Emergence	Yes	Yes	Yes	Yes
7. Human	Emergence reproduction	Yes	Yes	Yes	Yes
6. Animal	Emergence reproduction	Yes	Yes	No	Yes
5. Plant genetic societal	Emergence reproduction	Yes	Yes	No	Yes
4. Cell	Emergence reproduction	Yes	No	No	Yes
3.Control mechanism cybernetic	Elaboration	No	No	No	Yes
2. Clockworks	Elaboration	No	No	No	Yes
1. Static strucure	Elaboration	No	No	No	Yes

These conclusions are :

a) all empirical individuals go through a genesis phase, i.e. a period of constitution, from static structures such as planets, stars and galaxies, to social systems which are created by entrepreneurial human beings
b) at the end of the genesis period, all empirical individuals show a perpetuate dynamic which maintain their identity. The perpetuate processes are of different modes : static and dynamic equilibrium, negative entropy, life, and symbolic interactions to perpetuate social system.
c) The higher the level, the more complex its dynamics : 1) levels from 1 to 4 have three functional dynamics : genesis perpetuate and destruction, 2) level 5 and 6 have four with

the adding of development dynamic to the previous three ones, 3) level 7 and 8 have the five dynamics.

d) Identity and existence cannot be separated from level 1 to level 7, biological mutations affect living species but are beyond the capabilities of empirical individuals. Human beings are not (yet ?) able to undergo biological mutation, but they do have the potentialities for psychological and intellectual conversions. Only level 8, that is social system, can reorganize their identities and go through new phase of genesis.

If we accept a rough approximation, the empirical world would appear to be divided in three mains sections as regards its dynamic properties. The first one contains levels 1 to 3 it concerns matter, energy and information. The second one includes levels 4 to 6 and concerns living beings. The third one defined by level 7 and 8, contains consciousness. These three sections match a very old and traditional way to divide the empirical entities that constitute the whole Creation : the three realms : matter, life and spirit.

3.2. System/environment dynamics

The second classification we adopt was defined by F. Emery and E. Trist (1965). They proposed to categorize system dynamics by two factors a) do they take place in the system or in the system's environment? b) do they impact the system or the system's environment? Table 3 presents the four types of dynamics which result from this categorization

Table 3 : The four system/environment dynamics

Process localization Process impacts localization	System (1)	Environment (2)
System (1)	L11 Intrinsic dynamics	L21 Environment→system dynamics
Environment (2)	L12 System→ environment dynamics	L22 Induced environment dynamics

If we combine both classifications, we obtain the results shown in table 4 from which we can derive three new phenomena : system progress in autonomy, emergence and recursiveness (see below)

Table 4 : Localization of functional dynamics by levels

System complexity level	L_{11} Intrinsic dynamics	L_{12} System/environ-ment dynamics	L_{21} Environment/ system dynamics	L_{22} Inducted dynamics
8. Social	Transformation Developement	Strategy Recursiveness	Collective learning.	Turbulence Clustering

	Self maintenance Emergence		Acculturation	Reactivity Heterogeneity
7. Human	Transformation Death ? Development Self maintenance Birth and emergence	Strategy	Learning	Clustering Reactivity Heteroge-neousness
6. Animal	Death ? Development Self maintenance Genesis	Teleological actions. Reactions	Taming	Reactivity Heteroge-neousness
5. Plant genetic societal	Death ? Developemnt Self maintenance Genesis	Téleological influences	Tropism	Heteroge-neousness
4. Cell	Self maintenance Genesis			
3.Control mechanism			Genesis Destruction	
2. Clockworks			Genesis Destruction	
1. Static strucure			Genesis Destruction	

3.3. Systems progress in autonomy

Table 4 shows : a) level 1 to 3 have no intrinsic dynamics, b) genesis and perpetuate dynamics, which are under the control of environment for levels 1 to 3, since the existence of atoms, molecules, liquids, gas, and DNA depend on physical forces, shift to the control of the empirical individual for level 4 and beyond. C. Bernard (1878) pointed out this phenomenon by defining the living being as a "milieu" which separates from its environment by getting autonomy vis-à-vis its environment. The higher the level, the more functional dynamics come under the control of the empirical individual . This means the system complexity hierarchy can be seen as a scale for measuring autonomy among all empirical individuals.

3.4. The emergence phenomenon

For level 4 to level 7, C. Darwin (1859) showed there are strong arguments that a higher level "emerges" from its immediate lower level. The phenomenon of emergence states that an individual of level N comes into existence through interactions of empirical individuals belonging to level N -1. These interactions create new properties which cannot be anticipated, nor they can be logically deducted from the properties of level N-1. For example : plants come from living cells, but cells in plant can differentiate and integrate into organs, properties which do not exist in unicellular living beings.

Symbolic interactionism in sociology states that social entities emerge from human individuals interactions. Therefore, social entities such as organizations are nothing but sequences of individuals interactions, as stated by D. Kast and R. Kahn (1972), and the very nature of organization is interactions.

Emergence is a phenomenon in which continuity and disruption coexist. This statement means that Aristotelian logic does not hold in organizational thinking. Research and concepts about organizations must deal with contradictions and paradoxes. Different scientific disciplines are concerned with the study of emergence, including artificial intelligence (Jean, 1997). In this session, J. M. Sauvage will discuss this point further in his presentation on emergence.

3.5. The recursiveness phenomenon

Sociologist G. Simmel established in 1918 that social entities are able to take out some aspects of real life and create a formal context where these aspects evolve independently. He gave as examples of this ability of formalization : games that were derived from war or hunting and art which transcend the real life. For G. Simmel sociology is the science of those social forms which human beings create. E. Hugues (1960) was the first scientist who mention recursiveness as a phenomenon when he stated the hypothesis *:"If sociology is conceived as the science of social interaction and of the cultural and institutional results of interaction, which become factors conditioning future interaction, then ..."* More recently A. Giddens (1984) emphasized the concept of duality of structure :"*Understood as rules and resources, structure is recursively implicated in the reproduction of social system…All structural properties of social systems, to repeat a leading theme of structuration theory, are the medium and outcome of the contingently accomplished activities of situated actors. The reflexive monitoring of action in situations of copresence is the main anchoring feature of social integration but both the conditions and the outcomes of situated interaction stretch far beyond those situations as such".*

We define recursiveness as the phenomenon by which every social system is able to build forms or structures through interactions between individuals, which once shared by all the members of this system, become a new context that influence their future interactions. Evidence of this ability is given by technologies. Once stabilized a technology become part of a new context for the development of future technologies.

Recursiveness can be easily understood within the frame of system dynamics :

a) an open system influences its environment by exporting outputs
b) this influence is minimal for one individual, but could be very significant for a population of same individuals. Populations that survive transform their environment in a way that facilitate their growth and development.
c) Individuals are able to adapt to a new favorable environment which become the new context of their development
d) Individual of high system complexity levels (human and social entities) are able to direct their action to influence their environment in a way that facilitate their development.

4. Cross fertilization between system dynamics and organization dynamics

Organizations are the highest level in system complexity, they possess every existing empirical dynamic processes, and therefore system dynamics will remain incomplete and probably unexplained without integrating organization dynamics,. On the other hand, organization dynamics are very difficult to identify and to understand because they represent the last steps in highly advanced processes. One heuristic way to discover these processes is to follow their evolution level by level, because it may be easier to study them at lower levels. Besides it is a strong argument to validate the existence of a dynamic organization

process, to find its trace in prior levels. The example of recursiveness is an emblematic one to show how organization and system dynamics can cooperate to bring new knowledges and new understandings.

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