Dynamics of Organizational Learning. An Axiomatic and Model Approach

Kazimierz Roman Sliwa
Universidad de las Américas - Puebla(Mexico)
A. P. #258, Santa Catarina Martir
72820 Puebla, Pue., Mexico
Tel/Fax: 52 22 292121
E-mail: kazik@udlapvms.pue.udlap.mx

Abstract

With computer tools that have recently become available, we can model, understand, and re-interpret many important concepts that habitually have had descriptive form. One of those concepts is organizational learning as presented by D. Schon and C. Argyris. Instead of searching for empirical evidences and applications of a single (simple learning) - and double learning (meta-learning) mechanism, the paper attempts to develop an axiomatic view of learning process exploring the model of Autonomous System - AS (by M. Mazur) as an organizational arquetype. Used as teaching instrument, the model linked with the systems modeling and simulation has proved to be a very stimulating and effective tool in the classroom.

Dynamics of Organizational Learning. An Axiomatic and Model Approach

Objectives

Recent review of the systems literature (Sterman 1993) covers only English written sources in the field. In other countries system thinking have also resulted in many interesting works. The paper attempts to present one of the most original systemic axioms proposed by Marian Mazur (Poland) - the model of Autonomous System (AS) which is used as a basis for modeling the problem under analysis. Another objective is to present a certain didactic experiment residing in the roots of the paper. Organizational learning is one of the paradigms of organizational theory discussed in many courses, causing - due to its conceptual and abstract contents - many troubles to students. For these reasons, 2 years ago they begun to build up and use in the classroom simulation models of organizational learning. The model presented in this paper stems from several compiled models elaborated originally by students and then slightly modified by the author. The model proposes to keep the variables within dimensionally acceptable limits called "parametrization" hereafter.

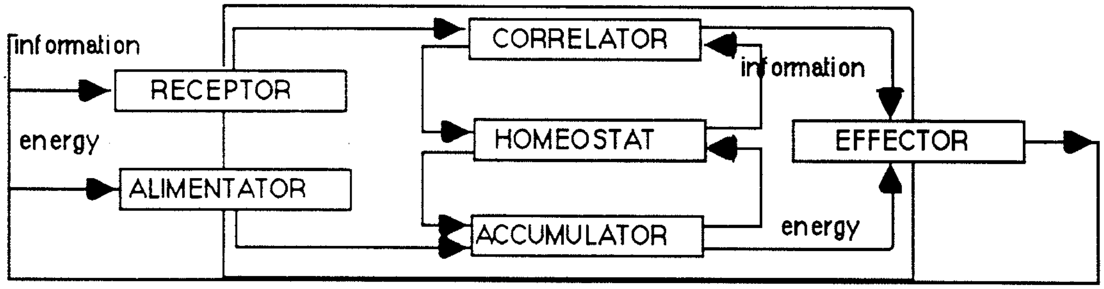
Autonomous System

Autonomous System is a generic metaphor of organization. Organizations are entities serving for controlling its internal processes; this requires not only a certain level of internal effectiveness but also depends on adaptive processes developed by the autonomous system. Adaptive processes determine external rationality of resources usage and provide us with a measure of internal effectiveness of the system. We can understand adaptive process as a constant interaction between the AS and its environment enabling continuous modification of its internal goals. The effectiveness must be, therefore, not a static criterion but it should be changing in accordance with external requirements. In that sense, we may say that the AS represents basic organizational attributes relevant for the learning process: single-loop (simple) learning consisting of error detection and past actions correction through internal effectiveness norms, and double-loop (meta) learning requiring those norms to be modified. Finally, as both learning processes are not momentary phenomena, the AS must preserve its ability to simple- and meta-learning over time. This will be called a deutero- or continuous learning. In other terms, the AS is defined as a system: 1) able to control itself, 2) able to design and adjust its control processes to the environment, 3) able to preserve the ability to control itself over time, and 4) all these functions must be performed according to energy constraints and environmental requirements.

Autonomous System's structure contains several components. Receptors, Alimentators, and Effectors are those parts of the AS that link it with the environment. Correlator, Homeostat, and Accumulator link input components (Receptors and Alimentators) with the output components - Effectors. Receptors acquire information from the environment and Alimentators receive the energy from the same source. Information processes occur in the Correlator where internal and external information is received, stored, and transformed. Energetic processes take place in the Accumulator responsible for the energy storage and use. In particular, any autonomous system needs 3 kinds of energy: 1) basic energy (for system maintenance), 2) working energy (for system outputs), and 3) free energy (for energy acquisition). Fig. 1 presents a structure of the AS.

Fig. 1

Structure of Autonomous System



Source: Mazur 1976, p. 164.

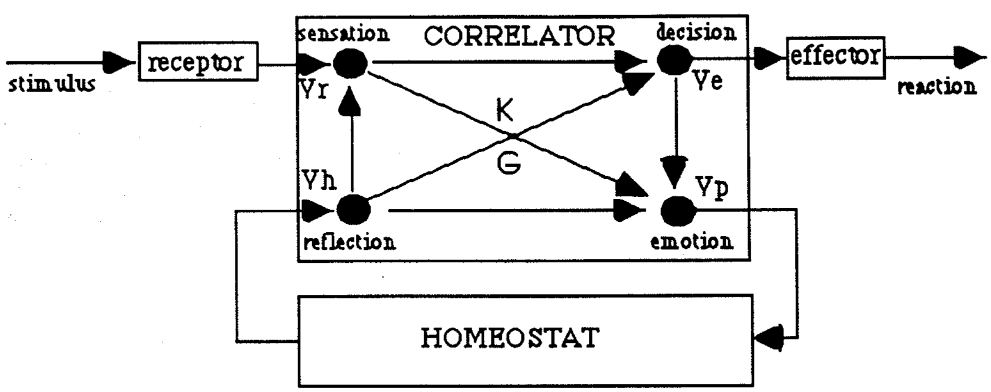
All components participate in complex and multi-layer energetic and information processes that determine the AS' survival ability. There is no information without energy flow and, similarly, any energy flow within the system requires and generates information. Both processes also shape the state of the Functional Equilibrium explaining the AS' changes over time (learning). Autonomous system (organization) can survive preserving its ability to receive, distribute, and efficiently use the energy according to functional equilibrium requirement of the system.

Acquiring information and energy from the environment is based on the positive feedback. Correlators and Accumulators simply react to certain states of the environment enabling the AS to receive and store information and energy. As they do not need to perform any other function, we argued that Correlator and Accumulator can not control the equilibrium process. In particular, they cannot preserve system ability to control itself - they cannot learn. In this context, learning means the ability to change system's objectives and control norms respected in the Correlator's and Accumulator's performance.

Learning takes place in the Homeostat which is a negative feedback based component. Homeostat compensates positive feedback existing in the Correlator and Accumulator and enables the system to manage its energy within pre-established limits. In this perspective, organizations can grow to the extent determined by the amount of available energy, and the growth itself alters previous energy equilibrium (relation between basic energy and working/free energy).

Fig. 2

Information Area in Autonomous System



Source: based on: Mazur 1976, p. 175 and further.

Information and Energy Processes in Autonomous System

M. Mazur applied originally its AS concept to psychological analysis and we follow his terminology in the paper. In order to keep the model simple, we assume that the Correlator has only 2 inputs (sensation and reflection) and 2 outputs (decision and emotion). With 2 inputs and 2 outputs, as the Correlator causes energy flow among its components, 4 kind of potential have to be distinguished: 1) Receptor Potential (Vr) - induced by Receptor into the Correlator; that process we call "sensation", 2) Effector Potential (Ve) - sent by Correlator to Effector ("decision"), 3) Perturbation Potential (Vp) - information provided by Correlator and sent to the Homeostat, and:4) Homeostat Potential (Vh) - influence performed by the Homeostat upon the Correlator.

As any information flow occurring in the Correlator requires energy (Correlation Energy), we need to introduce two additional terms: 1) Correlation Power (K) - the amount of energy conducted through the Correlator at a given time, 2) Correlation Conductivity (G) - property of the Correlator to throughput K. Fig. 2 presents the information area in the AS.

Autonomous System is decision oriented. This means that any reaction must be preceded by a decision determining a behavior of the Effector. Effector can not, however, react to any stimulus coming from the Correlator. Thus, decisions are made on the following basis: first, Correlator sends a message to the Effector; second, that message is evaluated according to its relevance for the AS (one of the Homeostat tasks); and third, if the message potential exceeds established level, decision is made and the whole system reacts.

Homeostat must contain a model of the Autonomous System. Therefore, it can only notice and react to those changes that occur within itself. Those changes are introduced by the Correlator (emotion and "Vp") and Homeostat compares it with its own equilibrium criterion determining if received message (potential) alters or not the equilibrium state. We may expect, thus, that:

* if the Receptor Potential (Vr) increases, the Correlation Power increases, too;
* increase of the Correlation Power causes the Perturbation Potential (Vp) to increase, and this:
* leads to incremented reaction of the Homeostat (Vh), unless received "Vp" is not harmful for the Homeostat equilibrium.

From the Systems Dynamics point of view it is very important to define a feedback existing between the Receptor Potential (Vr) and Homeostatic Potential (Vh). Receptor Potential behaves in a very same way as the Homeostatic Potential; increase of the Vh causes always an increase of the Vh. The relationship between the Vr and the Vh, however, is quite different: when Vr increases, Vh value must decrease (if the Autonomous System is to maintain its equilibrium state).

Another important point is the energy flow within the AS. Although in the next part of the paper we will discuss it with more details, it is vital to see energetic implications of two potentials (Vr and Vh) for information flow. Relationships existing between these components imply that the Correlation Power depends on the sum of Vr and Vh and on the Correlation Conductivity (K). Thus (Mazur 1976, p. 193 and further):

$$Vr + Vh = Vo + K/G \qquad [1]$$

and since initial potential (Vo) is equal to 0, then:

$$K = (Vr + Vh)\,G \qquad [2]$$

"K" value also determines the Effector (Ve) and Perturbation (Vp) Potentials and as it depends on the "Vh", then Homeostat can influence upon the "Ve" and, consequently, it can control the AS behavior. This means that the Homeostat maintains, through preserving its own equilibrium, the equilibrium of the whole system. Observing the formula 1 through 3 we can also say that information flow and storage depends on the energy. Information in this context is a difference between the potentials existing in the information source (e.g. Vr) and its destination (e.g. Vp), and that information flow requires the potentials transformation. Thus:

$$Vr = Vo + Ko/Go \qquad [3]$$

$$I(nformation) = + K/G \qquad [4]$$

The importance of the Formula 4 resides in its explanative character for various information processes. If information is a surplus of "K" over "G", then learning, memorizing, forgetting, and similar psychological and organizational phenomena must also have energetic nature. This may explain why strong, recent, and frequent stimulus have greater impact on system's behavior than weak, past, and rare one.

Another hypothesis drawn from our analysis concerns the interpretation of the equilibrium state. Homeostat interprets its state as complying with the equilibrium standard if and only if there is no significant difference between the "Vr" and "Vh"; otherwise, the Homeostat equilibrium state is endangered and the Homeostat's reaction is aimed at the reduction of that difference. Lack of equilibrium is an unacceptable difference between potentials and, therefore, equilibrium restoration is equivalent to reducing that difference.

The energy area in the AS has a very similar structure. System survives thanks to the energy supply from the environment; the energy is conducted through the Alimentators, stored in the Accumulator, and released when a decision is made in the Correlator. Similarly to what occurs in the Correlator, the amount and distribution of energy in the AS plays an important role in its behavior. Accepting physical analogies, we start with the concepts of the AS' Quality and Mass. We can interpret the quality of the AS as the efficiency of organizational setting to distribute available information among its components. Sometimes we may use, instead of "quality", the term "learning openness" referring to organizational readiness to share information among all its members. Technically, it is more difficult to be "open" for big than for small and more versatile one; company size, therefore, is another important factor for describing "learning organization". Organization size is referred to as the "mass" here. Again, accepting energetica version of the AS we can say that its power (information and data - "P") transformed by AS is proportional to the quality ("a") and size ("c") contained in the AS. Therefore:

$$P = v * a * c \qquad [5]$$

where:
"v" is the proportion coefficient of the AS or the amount of information transferred by 1 unit of "a" and "c".

It is obvious that higher potential flows to lower one and, consequently, the energy and potential distribution tend to become even. This phenomenon is normal in any system; in physics we may find special equation(s) describing that process. For our purposes we may accept that:

$$V = V_0 * e^{-zt} \qquad [6]$$

where "V" is present potential, "Vo" - initial potential, "z" - ratio of the AS' physical deterioration,
"t" - time, and "e" - natural logarithm basis.

Using [5] we obtain:

$$a = a_0 * e^{-At} \qquad [7]$$

where "a" is present quality of the AS, "a_0" - initial quality of the AS, and "A" - ratio of "getting older" of the AS..

"A" (ratio of "getting older") can be interpreted as a decrease of the AS quality and it is equivalent to a loss of initial energetical potential in the system. When this process is detected, the Homeostat can only counteract by increasing the AS size (organizational growth). Growth ratio is another factor involved in our analysis. Growth Ratio helps the AS to compensate negative effects of loosing initial potential. We can expect that the Homeostat determines the Growth Ratio on the "growing older" compensation level (at least) ; this means that the AS' growth will be uniform and proportional to its growing older. In this case:

$$c = c_g [1 - e^{-Ct}] \qquad [8]$$

where "c" is present mass of the AS, "c"$_g$ - terminal mass of the AS, and C - growth ratio.

Though mathematical expressions form important part of the AS theory, we may ignore some formulas linking the initial growth (8) with qualitative aspects of the decision making in the Homeostat. In particular, growth and learning in any system are very associated phenomena; presented theory attempts to prove that growth is a system's response to its qualitative deterioration and that this process mirrors system's learning in a long run. To analyze the growth and learning process, therefore, we need to combine both counteracting tendencies: deterioration and growth. For this reason we introduce the Dynamism Ratio:

$$n = C/A \qquad [8]$$

where "C" is Autonomous System's Growth Ratio and "A" its Deterioration Ratio; therefore:

$$C = n A \qquad [9]$$

If "n = 1" then growth is equal to deterioration and the Autonomous System is only maintaining its status quo. This condition is a minimum requirement for the single- and meta-learning of the Autonomous System. Yet an adjustment to present environment requirements (simple learning) is not sufficient and the AS must foster the deutero-learning. We may consider mathematical expression of the expanded growth (exceeding the deterioration ratio) as one of the important conditions for the deutero-learning. We have:

$$P = (v) (a_0) (c_g) (e)^{At} (1 - e^{-nAt}) \qquad [10]$$

where "P" - energy of the AS and "a_0" - initial quality of the AS (other factors explained earlier).

If we construct a graph corresponding to the Formula 12, we can see that the value of "P", after initial rapid growth and reaching a maximum point, begins to slow down and tends asymptotically to 0. That decrease of the AS potential can be interpreted as system's aging. Nevertheless, "P's" behavior does not give us information about how much energy the AS needs to survive. As we know, the AS acquires the energy from its environment and this process must consume part of the energy possessed by the AS. Let us call the energy spent for acquiring more energy the Idle Energy (Po). We may observe that the necessary amount of the "Po" increases when the AS' size increases and when its quality "a" decreases. Thus, due to AS' aging, the system requires increasing amount of the Idle Energy. Over time, the amount of the Idle Energy and "P" in the AS become equal and the system dies. Consequently, the first condition of the AS' survival is that the "P" must be greater than the Idle Energy (Po).

On the other hand, the Idle Energy spending is covered by energy supply from the environment. This part of the AS energy will be called Working Energy (Pw). As every process must consume energy, we may expect that the Working Energy must be sufficient not only for acquiring the Idle Energy but it also has to auto-supply itself. And finally, resting the Working and Idle Energy from a total amount of energy (P) in the AS, we obtain Free Energy (Pf). Therefore:

$$P = \text{Idle Energy} + \text{Working Energy} + \text{Free Energy} \qquad [11]$$

Free Energy is necessary for organizational learning and survival. This issue has been discussed extensively in the organization theory (Grandori 1987) and most authors emphasize the role of organizational resources for learning and survival. Although organizational learning is frequently considered as an intangible and resource free process, it also requires some energy. In a system with no Free Energy, any change of goals and policies is impossible and system's survival depends directly on straight capability of acquiring energy under constant internal and environmental conditions. If those conditions change, system has no energy to adapt itself and to search for a new equilibrium definition.

If energy is so important for the AS, then we must try to define its capability to control itself in changing environment using energy terms. The AS' ability to spend additional energy for changing its energetical status and redefining its objectives can be called the Control Factor (Cf):

$$Cf = Pf/ (Pw + Pf) \qquad [12]$$

All symbols of this formula have already been defined. We may notice that the Control Factor can change between 0 and 1; "Cf" is equal to 0 when the AS has no Free Energy and can only react to environmental changes within the limits established by its Idle Energy (stable environmental conditions). It is equal to 1 only when the AS does not require any Idle Energy (theoretical case only).

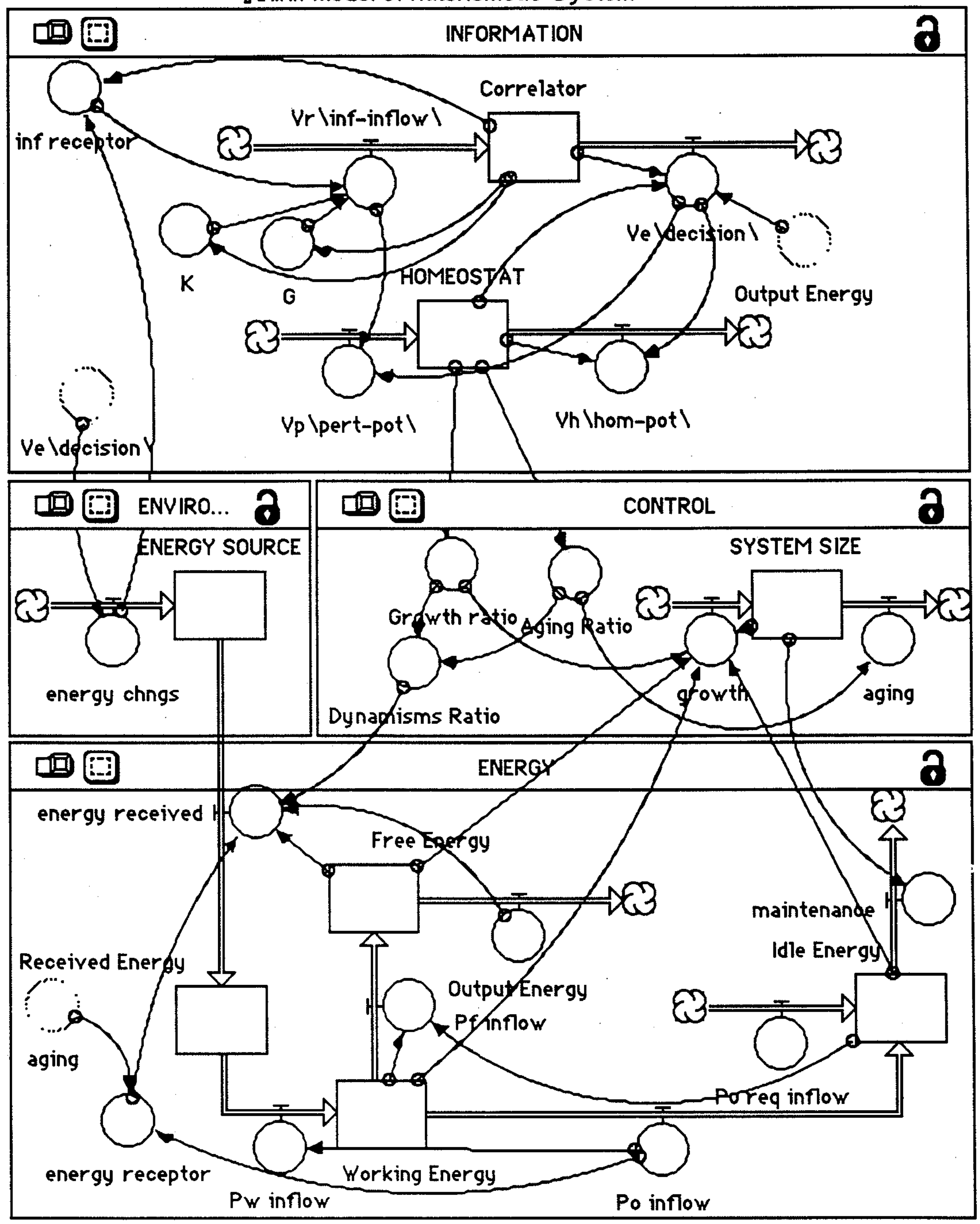
Learning in the Autonomous System. A Systems Dynamics Model

That model includes all presented variables relevant to the AS' behavior and learning. Although the graphic suggests that the model is complex and difficult to design, students - if they understand and follow simple mathematical reasoning underlying the AS theory - have no major problem with drawing variables and interrelationships among them. Variables definition, however, is more difficult. Since the organizational learning and Autonomous System concepts are rather abstract, there are 2 options in the variables development. First, we can accept any initial value (chosen arbitrarily) of starting variables. Another option is to parametrize all variables so that none of them can generate value "greater than 1". Though more laborious, the second option is much more clear for students, particularly when they come to interpret and understand final results. Figure 3 presents the :thinkTM model of the AS.

The model consists of 4 sectors: Energy and Information Sectors, Environment Sector, and Control Sector. First two sectors present information and energy behavior in the Autonomous System. Environment sector plays a secondary role and it generates energy supply for the AS. The stock of ENERGY SOURCE is defined, at the beginning, as an independent and random generator of the energy. When running the model, its specific value is modified by previous reaction of the system and by the quality and quantity of information receptors. Thus, during the simulation it is only a partially dependent variable. The Control Sector represents regulatory function of the Homeostat and it includes qualitative factors of the AS' behavior.

Fig. 3

ithink Model of Autonomous System



Source: author's elaboration.

Before we begin with the presentation of 2 runs of the Learning and Growth Model, let us start with some remarks on organizational learning as presented in the literature. In general, we can distinguish 3 theoretical postures in analyzing the problem. First, classical version of the organizational learning stress the role of the pragmatic and rational perspective; learning occurs with given organizational objectives and is aimed basically at both the external resources acquisition and clarification of internal preferences and conflicts existing among concerned participants (March, Simon 1958; March 1978; Winter 1975). Thus, the process starts with undefined organizational preferences leading finally to their modification. We may expect, thus, that organizational decisions are unpredictable and organization learns goals and ideas underlying decisions. The classical approach helps to understand why rational organizationa' premises are needed for actions and how to link actions with decisions and organizationai objectives. It also helps students to construct a clear and logical framework and interpretation of many intangible processes occurring in.

Second approach introduces the concept of the ambiguity into the learning process (March 1976). All acts and decisions have at the beginning the same expected value; they can not be compared within a rational context and, consequently, a choice among them is made on the random basis. Thus, we can interpret organizational learning as a process where fuzzy and not understandable past decisions acquire organizational significance through a posteriori justification (learning). Successful decisions and actions will be repeated and those that have failed will be rejected. The ambiguity approach has reached its peak in K. Weick's (1979) research who proved that the creation of new ideas starts with a complete uncertainty in the organization. Initial and random basis is submitted for later evaluation: experimented successes and failures make it possible to evaluate the value of decisions and to select those that should be used in the future as decisions guide. Thus, organizational learning is an evolutiotion causing that only successful organizational strategies can survive. Rational rules and a priori logic do not determine organizational learning; it is rather a selection process creating "from nothing" important ideas and theories.

Third approach stems from the seminal work by Argyris and Schon (1978) and its essential part is to propose a learning paradigm for organizational science. Single-loop, double-loop, and deutero learning have become unquestionable guideline for students and scholars. The paradigm approach explains how adaptation mechanisms conduct to organizational success and survival; past experience and present decisions are read and interpret in organization, corrective actions are undertaken (single-loop learning), experiences are accumulated and after passing a threshold they cause organizational objectives and policies to be modified (double-loop learning). Learning as a paradigm is clearly first attempt to analyze organizational learning as organizational and not individual phenomenon. In this context, organization is a place where social learning takes place and where the whole organizational history ("theory-in-use") is converted into decision trigger In addition, this is the first approach to state openly that the preservation of learning ability (deutero-learning) is critical for organizational survival.

All approaches use the environment as a basic assumption and a point of departure for organizational learning cycle. The environment is an object, goal, stimulus, and framework for learning which should be interpreted as organizational adaptation to it. K. Weick (1979) introduced the term "enacted environment" addressing organizational ability to select and define its proper environment. Thus, learning process is aimed at the perception and definition of the environment (construction and verification of mental models of the reality). This last point indicates that by no means the environment should be considered an independent variable, unless we consciously decide to overlook the feedback effect in the analysis. Thus, learning must explain to which extent the organization and its environment must respond each to another.

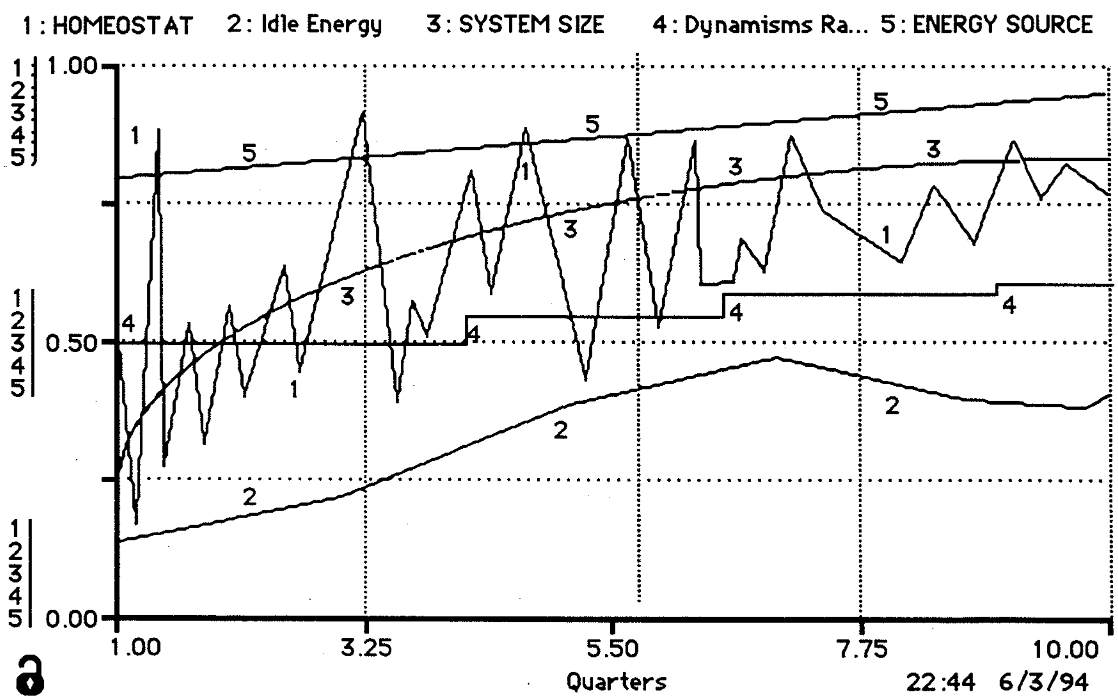
This short overview of existing learning theories serve for two purposes. These theories provide us with a point of reference for the interpretation of simulation results and, additionally, they give a valuable guidance for the Learning and Growth model construction. Second purpose is to show and prove that organizational learning problem, due to its intangibility and abstract character, is particularly difficult to teach; students, accustomed to concrete business terminology and concepts, have many problems in understanding the process of learning and, consequently, they usually reject practical meaning of organizational learning. Perhaps we can consider this argument as a rationale for using the Systems Dynamics methodology in the classroom.

In the light of presented theories we can expect that in organizational learning a priority must be given to reciprocal behaviors of the organization and its environment. It is interesting to follow the course of the model construction and interpretation. First, students learn theoretical background of organizational learning. Abstract theories, imprecise terminology, all these cause that it is difficult for them to operationalize the learning process. They trust theories but they do not understand them. Students, encouraged to accept everything that could be modeled (operationalized) and to throw away what must be trusted in the learning theory, try always to include as many variables appearing in the theory as possible. They interpret organizational learning as a process oriented towards resource acquisition (another learning paradigm: scarce resources in organization) and they use the AS for modeling intangible variables. A model challenges their imagination, especially in quantifying what is hardly quantifiable (it is worth mentioning that were students who proposed, 2 years ago, to parametrize a learning model - parametrization allows them to broaden a scope of included variables).

According to classroom experience, learning as the resources acquisition process appears to be the most controversial paradigm of organizational learning process. Without modeling and simulation, students would be confined to words game in discussing this issue; simulation model provides them with a more solid basis for accepting or rejecting it. For this reason, there are always 2 scenarios for organizational learning: first - assuming that the environment yields constantly increasing amount of resources to be divided among (see: Figure 4); second - contrary to the first, assuming an adverse tendency in the environmental capacity to supply resource (Figure 5). It is always expected that simulation results must significantly differ in both scenarios confirming that the scarce resources paradigm is well grounded. Surprisingly, simulation results are do not confirm this. In both cases learning (Homeostat behavior) shows the same tendency to oscillate around the system's size. In the context of acclaimed learning theories this tendency must be false; learning is believed to be organizational adapting to the environment.

Fig. 4

Learning and Growth in Autonomous System
(increasing ENERGY SOURCE)

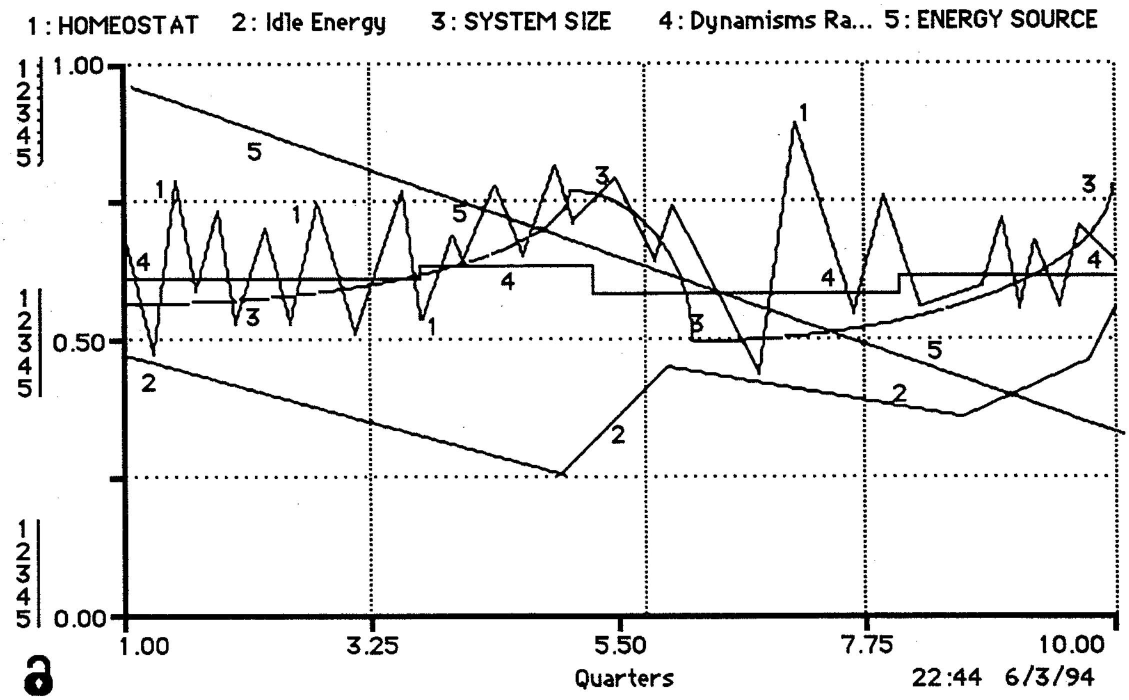


Source: approximate results of simulation.

There is another learning "paradigm" that helps to explain it. Learning does not occur between organization and environment but it is basically an internal problem of the Homeostat which creates a "mental" model of the AS. Discussing this topic students see the learning problem as verifiable phenomenon and they become systems thinkers on organizational learning.

Fig. 5

Learning and Growth in Autonomous System
(decreasing ENERGY SOURCE)



Source: approximate results of simulation.

Another important issue is the AS autonomy in determining its behavior in the environment. According to cited theories, the limits of the AS behavior are very constrained and depending on the environment state. This seems not to be true; if the Dynamism Ratio represents the AS' autonomy, then it should change in function of increasing or decreasing availability of resources in the environment. But it does not. Apparently, resources availability has little or no impact on the Dynamism Ratio and the Homeostat. This means that with no regard to the environment state, the AS tends to implement its "own" growth policy. Growth policy seems to be dominant and recurrent. The Idle Energy (along with its AS' interpretation) provide us with another interesting question. All organizational learning theories do not define what is a "scarce resource". Then, "how scarce must be a scarce resource"? The theory of AS and the ithink simulation model, in particular, give us a relative definition of the scarcity. We can run many different scenarios and find that in no case the Idle Energy intersects the value of the Homeostat's behavior. If it does, the Autonomous System perishes. The changes of the Working Energy (not presented here) correspond always to the Homeostat changes and the AS' auto-sufficiency depends primarily on the Idle and Working Energy.

Final Remarks

The scope of this paper and intention of the author do not pretend to present a competitive model of organizational learning. Instead, the paper attempts to point out some unclear issues of this process, paying more attention to teaching methodology than to organizational learning theories themselves. The theory of Autonomous System (still waiting to be available for a broad scientific community) gives us an excellent opportunity to exercise the learning phenomenon. Its use in teaching organizational learning (and as well other similar topics) has resulted in the creation of a very provocative and stimulating classroom environment. Without the Systems Dynamics methodology, and particularly Systems Dynamics simulation software, organizational learning would have to remain another dull, theoretical, boring, and academic topic causing trauma in business school students. Students, instead of memorizing abstract readings, live a hands-on experience in modeling one of the most challenging topics in their academic career.

The Autonomous System's perspective and simulation software provokes a discussion on important issues of organizational learning. Students learn and acquire a knowledge and they develop the attitude of questioning paradigms and breaking "infallible theories". Their criticisms increases and they become aware that in science there are no king's roads - on the contrary, there is a huge space for questioning and doubts, unless we are confined to juggling with words and concepts.

References

Argyris, C., and D. Schon. 1978. *Organizational Learning: A Theory of Action Perspective.* Reading, Massachusetts: Addison Wesley.

Grandori, A. 1987. *Perspective on Organization Theory*. Cambridge, Massachusetts: Ballinger.

March, J. G., and H. Simon. 1958. *Organisations*. New York: Wiley.

March, J. G. 1976. *Ambiguity and Choice in Organizations*. Bergen: Universitetsforlaget.

March, J. G. 1978. Performance Sampling in Social Matches, *Administrative Science Quarterly* 23: 434-453.

Mazur, M. 1976. *Cybernetyka i Charakter*. Warszawa: PWN.

Sterman, J. 1993. Desert Island Dynamics: An Annotated Survey of the Essential System Dynamics Literature. In *Proceedings of the 1993 International System Dynamics Conference*, Cancun, 466-475.

Weick, K. 1979. *The Social Psychology of Organising*. Reading, Massachusetts: Addison Wesley.

Winter S. 1975. Optimisation and the Theory of the Firm. In: *Adaptive Economic Models*, eds. R.H.Day, T. Groves. San Diego: Academic Press.