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CONTENTS

SCIENCE AS A SYSTEMS OF CYCLIC PROCESS OF GENERATION, PROCESSING, ACCUMULATION AND TRANSFER OF SCIENTIFIC ONFORMATION

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INTRODUCTION

This is a historical moment in the evolutionary process of mankind. It is a moment of great changes, not only in ways of thinking and carrying our activities, but also in attitudes with respect to unceasing innovations. Before we have had time to understand and assimilate an invention of discovery, something new appears which, in turn, has to be understood and assimilated.

This progress, the principal characteristic of which lies precisely in its rapid development, is much more noticeable in technology than in the humanities. Abstract ideas do not evolve as rapidly. In purely abstract matters related to philosophical thoughts, basically, we still maintain the principles of the eminent Greek thinkers, passed on to Western civilization by the Romans.

In Oriental cultures, typified bi the ancient civilizations of India and China, the situation is the same. Spiritual and religious ideas have not undergone many changes over the centuries. But now, in every culture, there is evidence of changes in mentality affecting discoveries. Typical examples of this occurred when it was proved scientifically that the Earth revolves around the Sun. another change in thought came about when the structure of the atom or the nature of energy was discovered.

Today, we view the world in a very different fashion than our forebears did only two or three hundred years ago. This includes notions of the structure of the Universe, the place of Mankind on the Planet Earth, and our individual, unrepeatable, selves.
In so far as transcendental ideas are concerned, the human being has barely evolved. The multitude of ideas developed from the successive epistemological theories have not answered our questions. Not even the most logical and coherent lines of reasoning based on chemistry and physics can explain the existence of the human being, the phenomenon of his life, or his emotional and sensory reactions. These remain mysteries.

Perhaps the human being has not reached a state of full development. He does not know even a small part of the world in which h is immersed and has no inkling as to the reason for such a situation. Perhaps in the future, when new goals have been achieved, with new discoveries and inventions, we shall find answer to all this puzzles. We shall then know who we are, what our mission in life is and what the future holds for the unique individuals that we are. Then , we shall possess the truth. In certain of my previous articles, I have maintained that once this moment is reached, mankind will have such material and spiritual perfection within its history that there will exist not further reason for existence on the planet Earth and it will be annihilated or will disappear.

These ideas assume that the life of the human being on our planet is a continuous path. As the poet says: "…through one´s steps one carves one´s path…". We join the path towards the search for that truth by means of science, and we contribute to science through research, the basic component of which is information: in this particular case, scientific information.

This rather lengthy introduction was necessary to focus on our main subject and to emphasize the importance and need for science within the historical development of mankind, one of the foundations of which is scientific information.

In accordance with my usual practice when dealing with a subject, I will lay the foundations on which I based my reasoning and will introduce those postulates. I will attempt to prove. I will therefore begin with the concept and nature of science and later continue with scientific information. I will go on to reflect upon the influence of science on the documentary process: the generation, processing, accumulation and transfer of the aforementioned information, and I will end this paper with a few general digressions.

CONCEPTUALIZATION OF SCIENCE

Science as a discipline, as one of the components of human learning, has been widely studied, among many, by Federico Mayor, Vernadsky, Eloy Terrón, Gutiérrez Ríos, Henri Poincaré, and other of various convictions.

A dictionary might define science as a body of methodologically formed and ordered doctrine constituting a particular branch of human knowledge to include definite knowledge of treat[1] things by their principles and causes. We should also remember that science is a set of acquired of a particular discipline.

Morcillo Corvetto, refers to science as experimental verification of knowledge from theoretical models.

From these definitions, we see that science is completely separate from philosophy as a result of its now tremendous development in recent times. It has even been thought that science can exist independently without support form other manifestations of reason or thought.

On the other hand, if we return to the origins of Western civilization, to the ideas of the Greek philosophers, science is considered as a mean of achieving wisdom, and consequently, truth, depending on the philosophy in question. Through science, we use reason to know and understand natural phenomena and occurrences. History is different, for here, we now facts, natural and real, by their succession through time.

Philosophy, which is understood to be the desire to acquire wisdom is a fundamental part of the human being, and so is science. An innate impulse in man drives him to discover the unknown. This impulse promotes his development, not only from that primitive humanoid to the human being in his present state of evolution, or what this could be in the future, but also in his development from child to adult during the first few years of his life. Of particular interest in this respect is the book by Professor Arntz "Information and the Emergence of Man: Boundaries in Evolution".

Robert K. Merton states that this curiosity or desire to find out and learn is so strong that it does not matter who makes a discovery or an invention, as sooner or later this would have taken place in any event. If this were so, the person who is makes the discovery should not be considered as an individual unto himself but as a social being, as part of a mechanism with a specific mission directed towards a predetermined end.

[1] We have to consider this expression as an aberration resulting form the lack of erudition of people who apply concepts without knowing their meaning.

Perhaps he is both or perhaps neither one or the other. The level of mankind´s development is still not high enough for us to solve this problem.

Science as a discipline within human learning as a whole is self-generated and self-generating. It acquires a universal dimension with interdisciplinary, intradisciplinary and transdisciplinary components.

Science implies a methodology that leads to research where in a logical and coherent methods is applied. Hence, today, when a logical and coherent is employed in the study of any branch of human knowledge, this is referred to as making science. We thus speak of historical sciences, juridical sciences, medical sciences, … chemical sciences… and even technological sciences. In this case science loses its particular meaning with respect to the knowledge of natural phenomena, and acquires a holistic character, likewise embracing "intranatural phenomena". Including those of the macrosphere, the microsphere and the nossphere.

SCIENCE AS A SYSTEM

Today, precisely because of the vast evolution in science with the subsequent repercussions on the activity of the human brain, which as a greater capacity of abstraction, strict compartmentalization can no longer be considered valid. Different fields of knowledge are interrelated and interdependent. For this reason it has once again become fashionable to apply the Systems Theory to any activity of the human intellect.

Perhaps science, as a discipline in itself, is the most suitable to apply to the Systems theory. We will therefore have to choose from amongst the various definitions of system the one that implies the study of the relations between a being and its surroundings. This being in not a single element but is composed of various interrelated elements which interact with their immediate environment. These units can form subsystems of differing levels so that as a whole they form a lattice, or network, of nodes with various entrances and exits, pointing in various directions. The different branches of the particular science will be the elements of the principal subsystem, where the first units that make up to lower-category subsystems, are determined by the subdivisions within the different sciences, all in mutual interaction. Thus, for example, organic chemistry, as a subdivision of chemistry, will be interrelated with and influenced by biology, history (in its evolution though the ages), ethnology, ecology, psychology and more… Ecology, on the other hand, would be interconnected with algriculture, geophyses, inorganic chemistry, parasitology and so forth… The different branches of science can successively be interwoven in to form one great system whose principal characteristics are found its open, evolutionary, complex and cyclic structure. This would not be dispersive but would have inlets and out-les.

The cyclic structure of science as a system, presupposes both reformation and transformation of its primary units which can pass from one to the other and later return to themselves. Let us consider, for example, certain historical elements that will be studied under political geography and later by historians proper… Or certain cybernetic elements that are studied in relation to the structure of the human brain to achieve "expert systems". They are later considered as simple computer components… This entire cyclic process is carried out with the intervention and aid of information that is now considered as a form of transferable energy within the cyclic evolutionary process of science. The difference, as V.A. Vinogradov sees it lies in that it is not consumed: it grows. Or in any case, at certain moments, it remains constant. This gives science a

dynamic character, allowing it to be studied within the context of systems and inventive dynamics.

It is precisely because science behaves as an open , cyclic and dynamic system, that the continual increase of information does not produce internal imbalances that could upset its behaviour. Information acts positively on its evolution. By, for example, breaking down certain units, new scientific subdivisions are created with new interrelations between these and existing subdivisions.

To study the behaviour of the different branches of science and their evolution in the future, models can be constructed, along the lines of Forrester, in which one of the flux-reflux parameters would precisely be information in its broadest sense. It could even determine the direction of its own evolution.

With this point, we conclude that science and information are inalienably related.

NATURE OF INFORMATION

Information is something about which a great deal can be said. It is of such importance within the context of the development of the human being and his situation in this complex and fascinating universe that one can always find new aspect of it.
Many authors have studied information, and come up with various theories. Among the most important theorists are Martín Leupolt, Silveira Saragoca, Shannon and his information theory, A.I. Kikhailov, Morcillo Corvetto, Brian Vickery, Michael Hill, H. Arntz, Manuel Carrión, G. Wersig, D. J. Foskett and many others.

Most of this authors consider information to be a "process, a consequence of the elaboration and processing of documents, that consciously condition the activities of the human intellect with repercussions in the development of mankind, either scientifically, technically or humanistically"

It should be noted, however, that information is something more than this. It is a "phenomenon" caused by the environment of the noosphere, which surrounds us and forms the development of our daily activities"[2]. It is inherent to the human being.

This double aspect of information as a process and a phenomenon provides it with a generalizing and ambipotent character. Due to its influence, man modifies his form of behaviour and his state of knowledge. Information constitutes the essence and presence of any human activity. It is subtle as the breeze (as a phenomenon), as persistent as the rain (as a process), as loose as the sand on the beach and as elusive as lost happiness… For these reason man, innocent, tenacious, and optimistic, pursues and attempts to dominate information. He tries to dominate it through science.

The difference between the so called European theories and those maintained by Anglo-Saxon authors, consist in that Europeans think information originates in and is elaborated from certain documents for their subsequent use. In other words, it is considered almost exclusively as a process. From here, we get the expression "documentation and information" and simply "documentation". The author of this paper studies information within the context of "ciencias de la documentación" as synonym for "information science", which includes bibliotechnology, archivology and documentation itself.

Author of the Anglo-Saxon school have a broadest concept of information, admitting its holistic character, and use the term "information science". Documentation

[2] E. Currás: "Las Ciencias de la Documentación Bibliotecológica. Archivología, Documentación, Información"; Barcelona, Editorial Mitre, 1982.

and Bibliotechnology are two of its components. This idea of information includes the two aspects of phenomenon and process, without differentiating between the two.

Many of the qualities and attributes of information can be applied to these two forms. At times this prevents them from being distinguished and studied individually. Our aim in this paper is to concentrate on the study of information as a specific process, as we shall refer to scientific information.

SCIENTIFIC INFORMATION

From my point of view, the concept of "scientific information" requires certain a bit of explanation for proper comprehension.

In previous publications, I have made several references to the adjective "scientific", I believe that it comes from the word "science" which implies the use of a logical and coherent method of work. Therefore, whenever this form is adopted, one can refer to something as "scientific". Any information prepared, be it by manual or automatic methods, will be "scientific information", no matter what subject it is applied to. In other words, we shall speak equally of scientific information when we refer to history, law, or physics.

It is true, however, that if we consider science to be the process by means of which we achieve knowledge of real things according to their origins and causes, we exclude here any branch of human learning that refer to abstract reasoning of mental discourse. Therefore, we treat only the subjects of the experimental sciences, such as, chemistry, physics, medicine, biology, geology, and technology.

Even though this latter concept is more restrictive than the former in that it reduce its sphere of action, its attribute, peculiarities, characteristics and methodology are similar and can be applied equally in either case.

It would perhaps be convenient to remember how the concept of scientific information has changed over the ages.

The term "information" has always existed, even though its existence was not known consciously, nor was it studied outside the sphere of linguistics. With the arrival of the Modern Age, man became conscious of everything that it meant, not only of its terminology, but also of its content, of its importance in the development of industrial processes, and of the experimental sciences themselves. More or less coinciding with the so called industrial revolution, the expression "scientific information" began to appear, referring to the subject it dealt with. Its methods of elaboration was manual. As society continued to evolve, the mass media became popular and referred to information. The difference between mass information and scientific information is accentuated. But halfway through the 20^{th} century, semiconductors have made their appearance on the social and scientific scene, and with them computers, cybernetics and computing. Machinery has replaced much manual work. Documentation techniques are not applied solely to the experimental sciences, but are progressively and successively used in every branch of human learning. It is now though that scientific information must refer to the method used and not to the subject. In certain Anglo-Saxon countries where computing is becoming common, this idea is becoming even more accentuated and is used almost exclusively as a synonym for documentary computing or automatized information.

We have now arrived at a point of coexistence between these three meanings of the expression "scientific information".

In the present paper, we study the influence of science on the global processing of information. We cannot conceive that there could be any difference between the three

meanings of scientific information, although for reason of explicitness, our reflections will be centred upon scientific information referring to matters related to the experimental sciences, where we shall include technology as an applied subject.

CONNOTATIONS OF SCIENTIFIC INFORMATION

SCIENTIFIC Information (SI), according to Morcillo Corvetto, is characterized by eliminating the difference between a state of uncertainly and another that follows immediately. This affirmation assumes an increase in knowledge, because the human being is in a perpetual and continuous state of uncertainly. He does not know the truth. He can only vaguely divine distorted projections of the truth based of facts that are real by chance, because he can perceive them only through his highly imperfect human senses which are subject to the idiosyncrasies of the individual perceiver and his surroundings. Ortega y Gasset referred to "man and his circumstances", and Karl Popper places man in a intimate relationship with his environment. In the modest opinion of the present writes, man can be considered as an individual and unrepeatable being in the "midst of a process which, based on the macrocosmos and the microcosmos, transforms and assimilates these to create a mesocosmos in which his psychic or spiritual component will act, supported by his material component"[3].

The idea of increasing the state of knowledge by means of SI is an optimistic posture. What might well happen is that the state of uncertainly will increase. This undoubtedly happens after certain discoveries.

It would perhaps be more suitable to refer to a "modification" in the state of knowledge. This is,, in reality, the mental impact of useful information.

According to A. I. Mikhailov, SI has the power to transform human activities and attitudes, hence giving it a social and moral dimension. Note that the concept of "human attitude" necessitated the assumption that information is a "phenomenon".

Martin Leupolt defines information as an ideal reflection upon objective reality. The concept of "ideal" refers to that part of the human mind concerned with cognition; whereas "objective reality" means the outside world in which the human being is immersed.

Likewise, mention should be made of the definition of Silveira who considers information to be a physical act accompanied by a psychic act. The physical act refers to the data, message or informative unit. The psychic act is undertaken by the mind in elaborating upon and grasping the physical act.

Also of interest is the definition of Klitke who speaks of parts of a whole which, when united, allow research and future tasks to be carried out.

We can also mention Alfred Marshall. He tells us that the best inheritance one generation can leave to the next is ideas transformed into information. Foskett also emphasizes the societal facet of the issue in staling that information is the social memory mankind.

In a recent talk, Brian Vickery affirmed that information is an end, not a means. He perhaps gave this too much emphasis. However, it can be assumed from this that information is a mean to science and truth.

By extrapolation, all these definitions can be applied to SI and can be adapted perfectly to the concepts described above.

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[3] E. Currás: "La Información como Cuarto Elemento Vital y su Influencia en la Cultura de los Pueblos"; speech at the Real Academia de Bellas Artes y Ciencias Históricas de Toledo, Typewritten manuscript, Toledo, 1986.

From the aforementioned, we can deduce that SI is dynamic: “the conformation of facts to make them intelligible”, and has an ontogenic properly, at is governs man´s mental activity, and consequently, his evolution to a human state in his social and universal projection. We should consider the pluralistic aspect of SI: it is not unique, it is plural, diverse and evolutionary.

All these characteristics of SI should be taken into account when carrying out a study of its positive and advantageous use for man and where its processing has to be considered with the aid of science.

PROCESSING OF SCIENTIFIC INFORMATION

Considering now the practical process of converting scientific information into something suitable for use, the characteristics of this process have to be analyzed as well as how these can be influenced by science.

In any information activity, the following processes should be considered:

-generation
-analysis and adjustment
-accumulation of storage
-transfer and communication

by means of which the data, or unit of useful information, is extracted from is context in an unknown situation forming part of an anonymous whole, to become a known protagonist, from which it will arrive at whatever destiny its future user might need to give it. It thus acquires a utilitarian character and a transcendental value, as it can affect so many human activities, depending on the type of data with respect to a given subject which influence the ontogenesis of the human being.

With respect to the generation of scientific information, we shall study its origin and its interaction with science as well as the influence of the latter on the formed.

Interaction between science and SI is mutual. Science generates SI which, in turn, generates sciences when it is used as a primary tool in its development. This is a continuous, cyclic process. It is not reversible and is evolutionary in ascending sense. With an increase in science, the generation of SI increases and this brings about more scientific wealth, today considered as accumulated learning. The process can be infinite. In practice, it will end when man´s existence ends on the planet Earth assuming human life is not moved to other planets or space ships outside our present atmosphere. And who knows whether that day will arrive?

The uncontrolled increase in scientific information could be highly detrimental to mankind, impairing his way of life and his internal –perhaps mental- balance. The brain picks up the information it receives and responds to this external stimulus to reach an “amorous” or homeostatic state. If, however, the quantity of information becomes greater than the assimilative capacity of the brain, it will be incapable of achieving a balanced state.

When, however, SI is elaborated in such a way that it can be rationally used to the advantage of science, it can be channelled toward good aims.

Misuse of SI can be tremendously detrimental to the human being, both on an individual level and socially. How many catastrophes could occur!

In fact, the influence science has over the present generation of SI cannot be analyzed so superficially. This is a transcendental matter and should be considered from different points of view depending of the scientific concept in question and according to

the branch of science to referred to. Results can be positive and negative, and can likewise affect diverse aspects of the lives and activities of men and other living creatures, economically, ecologically, and even spiritually. Our capacity to discern between good and evil and SI itself will be fundamental in obtaining positive results, for, according to Federico Mayor, science is the pillar of mankind, and at the same time it leads us to for foresee and project the future.

Let us now consider what the influence of science, in a general sense, could be on the process of analysis and adjustment of scientific information. The primary aim is to make it comprehensible. We have already mentioned that information, among other things, comprised a systematization of facts to make them intelligible. These facts can equally be real or abstract and are contained in documents presented in the form of sings of normal writing or signs that can be read by diverse mechanisms. They must be comprehensible to allow subsequent use. Information that cannot be utilized is pointless and can therefore be discarded.

The utilization of SI presupposes the initiation of mental activity requiring psychic and physical effort. It therefore entails philosophical and scientific factors as well as psychological, anatomical and biological ones.

For examples, this work principally consists in studying the documents and extracting from them the required data containing the desired information. Likewise, classification systems must be created along with ways of cataloguing and indexing. What is read must be understood to extract and summarize whatever is essential. All this requires intellectual work for which science merely provides the experience achieve in the past. A good part of this work requires originally and inventiveness. Of course, through science, these qualities can be accentuated in the individual, either through genetics or natural evolution.

Likewise, to have at hand SI with useful, reliable and honest data that is intelligible and can be assimilated contributes to the advance of some part of science, and hence contributes in general to the development of mankind as a whole.

Mental activity is also required in the process of accumulation or storage of scientific, information. All human activity implies mental activity by definition.

The activity involved is directed towards the creation of ways of conserving and recuperating information in its most varied aspects, from the simple ordering of the documents themselves to reading apparatuses (recuperation) using lasers. Not should we forget the different forms of storing information. Foskett states that information originates from ideas which, when grouped together to form sets (of words, or texts[4]). In this respect, place refers to data support and not topographical location.

Storage and recuperation does not just refer to the place or the isolated way in which data are found. It can also refer to the way in which the document itself is presented as a book, leafled, etc.

Hipólito Escolar defines a book as an ordered set of messages that allows one to overcome the barriers of time and space. Another definition speaks of a tool that considerably increases our memory capacity. Written information, which can be stores and recuperated, certifies something. It leaves a record of occurrences and facts “put down in black and white”, as the popular saying goes.

Science, in the last few years, has provided us will marvellous equipment which make conserving, storing and recuperating SI is extremely easy. Any data can be within our grasp in an unbelievably short time. The problem lies in economic limitations. Certain equipments is still too expensive for the average person, and access is not

[4] Author´s note

universal. However, precisely because of the rapid development of science, there is hope that situation will improve shortly.

There is no point whatsoever in having information in situ if the users are far away and have no access to it. Information therefore has to be transmitted and communicated.

In fact one cannot speak of information as existing if this fact is not transmitted and perceived, i.e., communicated. Data, a document, or a unit of useful information can easily sleep the deep sleep of the just, because, if it does not wake up and travel towards the person who requires it, it will never become information.

It is in these communication processes that the influence of science is best noted. In less than two hundred years, communication media have undergone truly remarkable changes. Who now thinks of the horse or stage coach as a means of transport of information? Pneumatic post is no longer used except within certain business enterprises. Nowadays, information travels by plane, and this is the slowest system, through the air, by cable, by satellite, using an array of almost incredible technological developments. Paradoxically, for the sake of speed, the "messenger" has returned, but he is now mounted on a mechanical horse. The very postal system which was so commendable for its perfect functioning is beginning to be outmoded and only suitable for private long-distance exchange of family information. Its situation will deteriorate even more when video-data, numerical optic disks, tele-text and other equipment can be used on a mass scale. The picture will change completely. Due to the influence of science, development will be a cyclic, not a lineal process.

SCIENCE AND SCIENTIFIC INFORMATION

Now that it is clear that science as a whole exerts a decisive influence on each an every step of the information process, we shall return to our earlier line of reasoning in which science was considered an open, complex, evolutionary and cyclic system subject to study under the aspects of systems dynamics and inventics.

Science will influence scientific information by conditioning its flow in and out of a given system. But information will also affect the functioning of the scientific system. The feed back loop needs a sufficient flow to maintain a balance and for an equal flux out of the system to be created. The two types of information – incoming and outgoing- will not be identical. This will imply a lack of activity with side the system, a lack of work or of energy consumption. In other words, there will be scanty elaboration of information received -of raw materials -to produce an output (a product) of useful information. This means the system has died, and there will be no scientific activity- no science.

But science does exist. At least we assume this in light of the new inventions and discoveries that appear almost daily. Science is alive. Our reference system shows evolution, be it discontinuous –in phases or stages that are difficult to foresee.

Science enables us to study the past of mankind and our universe. It helps us, with greater difficulty, understand the present. And we believe it can helps us to foresee the future. Mankind´s greatest hope is to believe in science and through scientific information, to overcome the evils we suffer and to free ourselves from these in the future.

One of the missions of system dynamics and systems engineering is precisely to construct mathematical models with various interrelated variables and parameters to that they give value to each other and their performance is observed. Mathematical calculations are long routine procedures; but the computer has arrived to aid the poor

human being and increase his capacity for action. Today, tedious calculations no longer exist.

René Thom´s theory of catastrophes is based on the study of variables and functions of a system in discontinuous evolution, and hence predict those moments in which the system will undergo sharp changes –for example, mutinies and revolutions. Mind you, this cannot always be applied to purely social problems. For example, it will be easy to predict those periods in which there will be vertiginous scientific evolution with many new inventions and discoveries which will imply a transmutation of the system for this to continue working. In terms of cyclic systems, with which we assume science should be grouped, prediction can be made more easily, as the recycling of variables and functions implies a more homogeneous evolution and, despite the existence of information inlets and outlets, the set has a more uniform behaviour.

In times of catastrophe –of sudden change- a functional imbalance is created. This causes a greater liberation of information which has to leave the system for it to return to its normal functioning.

To our way of understanding this is the present situation. Science has undergone a drastic change with respect to its function as a system. This was brought about by the numerous inventions and discoveries of recent times. Consequently, a great deal of information is being released. This information we will term as scientific for reason explained above. This is the information that inundates us and leads to think that we are in an age of informationism, as I suggested in 1982 article. But in fact, information has existed ever since there has been life on the planet Earth.

It is this idea of an epistemology based on informationism that leads us to confuse “Information” with “information technology”. When we refer to the information society or the information industry, we should surely emphasize that it is “the society of information technology” or the “information technology industry”.

Where would mankind go without information? People are naturally sociable. They need similar beings to develop and complete their life programmes: life programmes that contains reciprocal and continuous exchange of information within the context of a system called society. A. I. Mikhailov states in his preface to the book “ Social Aspect of Modern Informatics” that society exists because there is information. It is true that without information, society as such would not exist, for related ways of life imply interaction between elements that have collected in some form of association, it is therefore impossible to imagine interrelation without communication, or without information.

It is precisely due to the desire to exchange information that the need to know and make known arose –that is, knowledge, research, reaching out for science. Socrates said that the virtue exist in learning. Let us hope that our future learning based on information, will lead us to the good and to more well- being and will eliminate the evils of our time.

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