EPISTEMOLOGICAL APPROACH OF INFORMATION CONCEPT WITHIN DIFFERENT DISCIPLINES

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Abstract

Today, information - rather than labor or capital - is becoming the key factor in production. Thus, the actual so-called "Post-Industrial Society" is the Information Society, whose fundamentals are Information Science and Information Technology. In this paper, an attempt is made to outline the epistemological[1] approach of information concept within different disciplines as well as the need of a general higher education in Information Science. Problem solving, decision-making and paperwork reducing are some of most frequent information processes currently involving engineers and managers in multi-disciplinary teams, within a company. Even if electrical, electronics and computer engineers are already involved in some information transmission theories, models and methods, all engineers have to know how it is possible today to generate, process, communicate, store and use information in the most advantageous way.

1. Introduction

"Information concept - as it was employed within different disciplines, during many years - had a heteroclite[2], ambiguous and polyvalent[3] character, despite its considerable heuristic[4] value"[5]. Over the years, each category of information professionals succeeded to

[1] *Epistemological*: related to the epistemology, i.e. to the study or the theory of the origin, nature, methods, and limits of knowledge
[2] *Heteroclyte*: being out-of-the-way, departing from or opposed to the usual/ established rules
[3] *Polyvalent*: having more than one valence or value
[4] *Heuristic:* having usefulness for scientific discovery

develop its own system of concepts, methods, laws, models, theories, terminology, procedures and standards concerning the information generation, transmission and use. There are now needs to build some bridges between all these professions, in order to allow them better understand each other, to co-operate and to optimize their information-based processes, within the information science.

Information is for many decades and even centuries, consciously or unconsciously - the *working object* of numerous professionals around the world as well as the *fundamental link* between them. Examples of such professionals include writers, librarians, bibliographers, archivists, information and intelligence officers, journalists, electrical, electronics and computer engineers, computer programmers, systems analysts, database administrators, mathematicians, biologists, physicians, linguists, scholars, etc. Over the years, each category of these information professionals succeeded to develop its own system of *concepts, methods, laws, models, theories, terminology, procedures and standards* concerning the information generation, transmission and use.

Consequently, there is now a need to build some *bridges* between all these professions, in order to allow them to be better understanding each other, to co-operate and to optimize their information-based processes.

2. What is Information?

According to Tague[6], information may be "*a product, an operation, a process, a communication between two persons, a message transmission, a state of awareness, an answer given to a question, the results of an experiment or a test, a characteristic, the rarity of a received message, the utility of an answer to a question or the consequences of a decision*".

Machlup and Mansfield[7] found and expressed ten different meanings of word *information*:

"1. Something that one did not know before,
2. A clue,
3. Something that affects what one already knows,
4. How data is interpreted,
5. Something useful in some way to the person receiving it,
6. Something used in making decision,
7. Something that reduces uncertainty,
8. The meaning of words in sentences,
9. Something that provides more than what is stated,
10. Something that changes what a person who receives it believes or expects".

According to other authors, *information* may represent *a measure of the organization degree of a system* (for example, *of a message* - for Shannon and Weaver[8] or *of living things*

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[5] Le Coadic ,Y.F. – *Information Science* (original title in French), PUF, Collection What Do I Know?, no.2873, Paris, 1994

[6] Tague, J. – *Information Science – Theoretical and Interdisciplinary Aspects* (original title in French), UNESCO, Paris,1984

[7] Machlup, F., Mansfield, V. – *The Study of Information: Interdisciplinary Messages*, John Wiley, New York, 1983

– for von Bertalanffy) as well as *a measure of tidiness of fluid molecules contained in a receptacle* (for Boltzmann).

For Shannon[9], well known by all electronics engineers in the world, if a given situation is highly organized, it is characterized by a reduced degree of randomness (or of choice); that is to say that *entropy* - as measure of the degree of randomness - is law (or information is few).

For Debons[10], *information* is related to some cyclic processes of organization and processing of *data* (as raw facts representing events, from which inferences or conclusions can be drawn) in search of more and more useful meaning and benefit for information's users. Debons stated that *information* (as a set of answers to questions like what? who? when? and where?) is always necessary in order to earn more and more *knowledge* (as a set of answers to more complex questions like why? and how?) as well as in order to get wisdom. According to him, all living things – human beings, animals, plants – require *information* in order to meet the most important needs of their life: survival and reproduction. The word *information* may be used in different contexts: as a commodity, as energy, as communication, as facts, as data, as knowledge.

Trauth found (in 1978) twenty definitions of concept *information*. She categorized them into four groups of meaning:

"*1. Definitions stressing the external movement of information itself*

2. Definitions assuming that information would be a process-oriented concept in that movement from information source to the information destination

3. Definitions viewing information as an object operating within some dynamic process (such as decision-making or problem solving)

4. Definitions seeing information as fact or discrete data elements"

Based upon these definitions, Debons concludes that words *data, information* and *knowledge* can be used interchangeably, depending on context and intention. Hence, an integrative approach of these concepts and of their applications would be "much more effective".

For purposes of this paper, let us consider the following definition of *information* concept:

> *Information* = set of data, ideas, findings and / or creative works realized and transmitted by living or non-living things. In a given context, information has a specific *meaning*, which can be communicated, stored and preserved by means of an *information conveyor* and an *identification code*.

Information concept may be thus defined as a collection of *data* representing facts (and structured as answers given to a set of questions) and organized in such a way that they have additional value beyond the value of the facts themselves. *Information* concept should not be confused (see Fig.1) with concepts of *data* (related to raw facts or events) and of

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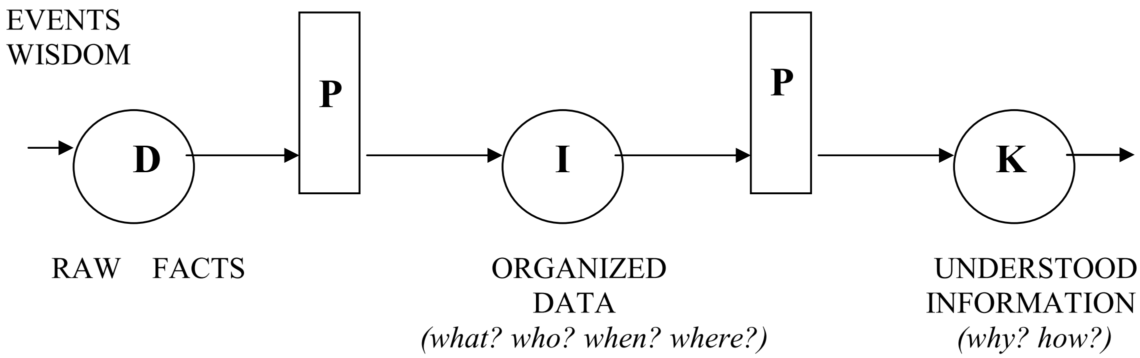
8 Shanon, C.E., Weaver, W. – *Mathematical Theory of Communication* (original title in French), CEPL, Paris, 1976

9 Claude Shannon was a telecommunication engineer; he is considered today as one of the fathers of Information Theory. He published in 1949, at University of Illinois Press, the book mentioned above. It was a fundamental and very influential book reprinted, meanwhile, many times.

10 Debons, A. and others – *Information Science: an Integrated View*, G.K. Hall, Boston, 1988

knowledge (which relates to answers given to another set of questions and representing understood information). The transformation of *data* in *information* and of *information* in *knowledge* can be viewed, according to Debons, as "*part of a spectrum of cognition that characterizes human competence in dealing with life's events. This spectrum is hierarchical, each transformation representing a step upward in human cognitive functioning*".



D – Data; **I** – Information; **K** – Knowledge; **P** – Process

Fig.1 - From *Data* to *Knowledge* and from *Events* to *Wisdom*, through *Information*

Knowledge concept may represent either the knowing process or its result. *Knowledge* represents organized and coherent information that has been understood and evaluated by knowledgeable people (especially in the light of their own experience); it is thus similar to the concept of *understanding*. *Knowledge* is a very important, even vital, act allowing to human beings to understand, to learn and to become wiser. Understanding what is true, right and lasting represents *wisdom*, another basic concept. It means sound judgment and ability to apply what has been acquired mentally, in order to achieve some goals. Thus, *to know* means also to gain power over one's environment (including people and other resources). "*Knowledge is power!*" stated the worldwide known British philosopher Francis Bacon. For this reason, access to information was denied to "ordinary people", and monopolized for a long time by some who succeeded in strengthening their own power. **Diffusion of public information to all interested persons** was one of the fundamental principles of the republican form of government established by the US Constitution and announced by the third US President Thomas Jefferson (1801-1809) in his inaugural address of 1801. Meanwhile, other democratic countries around the world included the right of access to public information as a fundamental human right.

In daily practice, we are usually dealing with a so-called *common knowledge* (allowing us to simply identify objects and to anticipate their behavior) and with a so-called *scientific knowledge* (enabling us to understand completely and precisely some phenomena, processes, objects, etc).

3. What is Communication?

In day-to-day life, the words *information* and *communication* are often considered synonymous; but, according to Escarpit[11], "*communication is a process and information is its product*". In other words, information is the effect (result or product) of an object of the third world - as it was defined by Popper[12] - on an object of the second world. *Being informed* is the result of *communication*….

Communication is usually seen as a *transmission of information*. It is obviously a *confusing approach* because *communication* involves **a transfer of *meaning*** and *information transmission* **a conveyance of *energy***. *Transfer of meaning does not always involve an energy transfer*! In Fig.1 data, information and knowledge may be transmitted, for example, from a process to another. According to Debons, *data transmission* represents a transfer of symbols (which may or may not have the power to inform their receiver/user), *information transmission* is a conveyance of energy from a source to a receiver / user (in order to extend a state of awareness and related intentions to this one) and *knowledge transmission* is a conveyance of understanding. But, according to the same author, *communication* is *information transfer* or *information transmission with intent (purpose)*.

3.1. Movement of Meaning (Information Transfer or Communication)

Communication represents the second step of a social model called *information cycle* (Fig. 2), similar to the *product cycle* in microeconomics approaches (Table 1.).

Analogy Product – Information

Table 1

STEPS	**PRODUCT CYCLE** (within an *economic system*)	**INFORMATION CYCLE** (within a *research system*)
1	PRODUCTION	GENERATION
2	DISTRIBUTION	COMMUNICATION
3	CONSUMPTION	USE

It includes three essential informational processes: process of *information generation,* process of *information communication* (or *information transfer*) and process of *information use*. According to this model, these three processes are **indefinitely reiterative.**

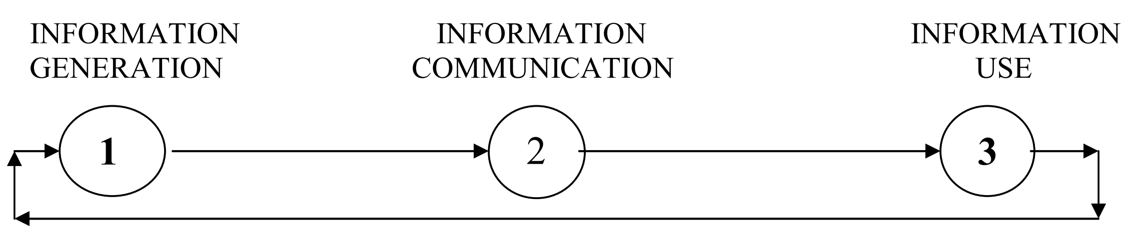


Fig. 2 – Place of Communication within Information Cycle (as *Social Model*)

3.2. Conveyance of Energy (Information Transmission)

[11] Escarpit, R. – *General Theory of Information and Communication* (original title in French), Hachette, Paris, 1990
[12] Popper, K. – *Objective Knowledge: an Evolutionary Approach*, Ed. Clarendon, Oxford, 1973

Another model of communication, much more known worldwide - especially by electronics and telecommunications engineers - is the so-called *Model of a General Communication System* developed in 1948 by Americans Shannon and Weaver, in their basic work entitled *Mathematical Theory of Communication*. Based upon some concepts, models and theories provided by Americans Nyquist, Hartley and Laswell[13], authors gave to word *communication* a very broad sense in order to include "all procedures allowing to one mind to affect another mind" (as for example, by written or verbal messages, by sounds or images, etc.). Weaver proposed to classify all possible problems of communication in three categories:

-A *technical* problem: how accurately can be transmitted the symbols of communication's message?

-A *semantic* problem: how precisely do the transmitted symbols convey the desired meaning?

-An *effectiveness* problem: how effectively does the received meaning affect conduct in the desired way?

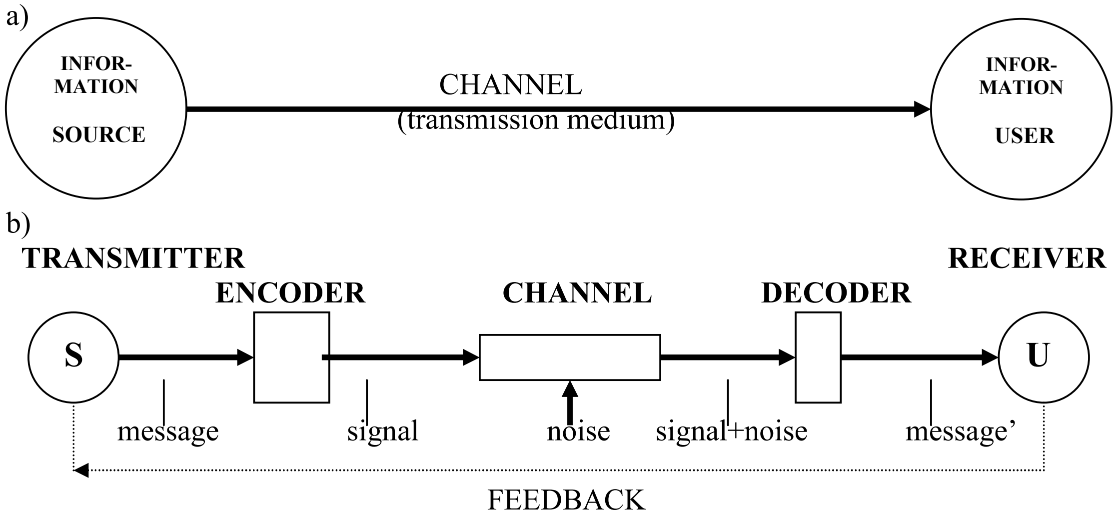


Fig. 3 – Adapted Shannon's and Weaver's Model of a General Communication System (as Physical Model); a) The Simplified Model, b) The Detailed Model

He recognized that all these categories of problems are closely interrelated and overlap in a "rather vague way"…Shannon himself stated that "*the semantic aspects of communication are irrelevant to the engineering aspects*"! "*But this does not mean that the engineering aspects are necessarily irrelevant to the semantic aspects*" – commented Weaver! Today, this fundamental work – known also as *Shannon's Information Theory* – is considered as "*an attempt to quantify the movement of signal through space and time*" (Debons). After 50 years it is obvious that **this model (Fig.3) and its concepts are fundamental in order to understand and solve ONLY the *technical* problems of communication** (as for example those related to channel efficiency and optimization of

[13] Laswell, M.D. – "*The Structure and the Function of Communication in Society*", in The Communication of Ideas, Editors Bryson, Marper & Brothers, New York, 1948

signal-noise ratio). The ***semantic*** **and** ***effectiveness*** **problems of communication have to be solved by Information Science.**

According to this model, an *information source* generates a *message* (containing generally selected written and/ or spoken words, sounds, images, etc.). This message is conveyed by a corresponding *signal* (converted from *message*, by *transmitter*) through a *channel*, to the *information user* (where a receiver converts the signal back into a message). The signal – as information conveyor – may be affected during it propagation through channel by *noise* (a general special concept including all possible unwanted impairments of signal and affecting its quality). This model included a feedback loop that was introduced by Norbert Wiener[14] – known as "the father of cybernetics" - in order to optimize the communication between source and user.

Telecommunication is a communication realized electronically. It is in fact a conveying of energy representing information (not of meaning associated to information!).

According to French researcher Le Coadic, "*It was made long time a basic conceptual confusion considering as being analogues the information concept of the mathematical theory of signal transmission and the information concept of human communication process. Many representatives of American and French schools of communication were victims or accomplices of an error made possible by this analogy. I am convinced that the measure of informational entropy is applicable only to symbols and signals, having nothing in common with their meaning. Confusing electric signals and human communication, one could consider that the last one may be authoritarian, directive and mono-directional (...) If analogy is always considered as being a fertile inter-disciplinary concept (facilitating the movement of ideas from a scientific field to another one), this concept may also block, by misuse, the normal evolution of knowledge (...)*"

According to findings of American researchers of the worldwide famous so-called *Palo Alto School of Communication* – authors of the *Interactive Communication Theory* – information exchanges between two or more persons are always the result of their mutual interactions within given context and environment. Efficiency of communication is strongly dependent to the specific limitations of information source, channel and information user.

4. Information Amount Measurement

During the first half of the twentieth century, there were many attempts to establish theories of information, information transmission and communication, especially in USA. Measuring the information amount within the information transmission process was one of the most important challenges of the past century.

According to the Shannon's *Mathematical Theory of Communication*, the concept *information* – which must not be confused with the concept *meaning* – deals not with a single message (having a particular meaning) but with a whole ensemble of messages. Hence, *information* relates not so much to what *one does say*, as to what *one could say*. That means *information* is a measure of one's freedom of choice when one selects a message (from many possible and available messages expressing a same idea). Because the information source generates statistical messages by successively selecting discrete symbols, it has a *statistical* nature. This statistical process is simultaneously *stochastic* (because its symbols are random

[14] Wiener, N. – *Cybernetics,* Wiley and Sons, New York, 1948

or conjectural), *"Markoff"*[15] (since the probability of each event depends on probabilities of previous events) and *ergodic*[16] (because any reasonably large sample of symbols tends to be representative of the sequence as a whole).

Because the message generated by information source is one selected from a set of possible messages, the information transmission system must be designed to operate for each possible selection not just the one, which is actually generated by the source (which is unknown). If the number of messages in the set is finite, it can be considered as a measure of the information produced when one message was chosen from the set (all choices being equally likely). As was pointed by Hartley, the most natural choice (practically useful, intuitively proper and mathematically suitable) is the logarithmic function.

According to Shannon, the **amount of information *I*** is measured, in the simplest case, by the logarithm of the number of available choices N. Supposing N different events having the same probability of occurrence p, where $p = 1/N$.

Occurrence of one of these events generates the information I, where:

$$I = + \log 1 / p = - \log p = \log N$$

Hence, the information provided by a message relative to an event (characterized by probability of occurrence p) is all so more valuable since the event was more unforeseeable. When a situation is highly organized (being characterized by a reduced degree of randomness or of choice), it is characterized by a reduced degree of randomness (or of choice); that is to say that *entropy* - as measure of the degree of randomness - is law (or information is few).

For a set of n independent allowable messages, each having its probability of occurrence p, the **entropy *H*** (as average information per message interval) is given by:

$$H = - (p_1 \log p_1 + \ldots + p_i \log p_i + \ldots + p_n \log p_n) = - \Sigma p_i \log p_i$$

Entropy may vary between *zero* (when it is associated with an extremely unlikely message) and a *maximum* value (when all the messages are equally likely).

5. Information Quality Measurement

Information overload, informational harassment, misinformation, huge paper work and negative bureaucracy are today the most common consequences of poor quality of information generated, processed, transmitted and used within information systems.

Consequently, it became necessary to evaluate continuously and critically the **information quality**, in order to be able to select the information according to user's own requirements and needs.

In order to be valuable, for example for managers and other decision makers, information should be more or less *accessible, accurate, complete, economical, flexible, reliable, relevant, secure, simple, timely, verifiable*, etc. Each of these information

[15] *Markoff Chain* (in Statistics) – is a chain of events whose probability depends on probabilities of previous events

[16] *Ergodic* (in Statistics): characteristics of a symbols sequence for which any reasonably large sample of symbols tends to be representative of the sequence as a whole

characteristics is to be appropriately measured and compared with some pre-established accepting/rejecting criteria…

According to the international standard ISO 9000: 2000 (Quality management systems – Fundamentals and vocabulary) the concept "quality" means the <<*degree to which a set of inherent characteristics fulfils requirements*">>.

Quality of information may and must be evaluated every time we receive, generate, process and/ or use it.

The information as a commodity is to be considered as an immaterial product, the so-called *information product*. It has not to be confounded with the material product accompanying it (material information conveyor as paper, CDs, etc.).

Quality of both these immaterial and material products has to be evaluated within the information market, by both the user and the provider, using specific criteria and tools.

Conclusions

1. New information and communication technologies – mostly developed during the last two decades! – are generating a new industrial revolution based on information. Every day, somewhere, new *information products and services* are offered to the market. This happens because the progress of these technologies enables us now to generate, process, store, retrieve and communicate - electronically or optically - information (in what ever form it may take: texts, sounds, or images) unconstrained by distance, time and volume.

This revolution is adding huge new capabilities to human inherently limited skills and even began to change *the way human beings are living and working together*.

We are certain that the widespread availability of new information tools and services will offer new opportunities to build a *more equal and balanced society* and to foster *individual accomplishments*. Thus, the information society has the potential to improve the quality of citizens' life and the quality of environment, to raise the efficiency and the effectiveness of organizations and to promote new forms of work organizations as well as the creation of new jobs, to strengthen industrial competitiveness and to reinforce social cohesion.

2. The function of Information Science is represented by *knowledge transfer from an individual to another and from a generation to another one*, with the *final goal* to facilitate humanity evolution.

3. Information Science is today a complex *interdisciplinary* scientific field intersecting Electronics Engineering, Information Transmission Theory and Signal Theory as well as Telecommunications Engineering, Computer Science, Mathematics, Logic, Psychology, Linguistics, Sociology, Economics, Management, etc. Its object is information as *process, product and state of awareness*. Information Science – as "the science of information systems" – is one of the pillars of the actual Information Society. Thus, it is very useful to become familiar with its concepts, models, methods, theories and laws.

4. For over 40 years, *Information Science* is an interdisciplinary field of study in an increasing number of major universities around the world (especially those from USA, Western Europe, Japan, Australia and South Africa).

5. It has been our observation that the interdisciplinary higher education in Information Science is not easy to engage. Often, the difficulties of interdisciplinary education are not fully appreciated by faculty members or the university. Some of these have

the tendency to perceive Information Science as an extension of their field of study. This serves to mitigate the essential interdisciplinary perspective of Information Science.

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