Journal of Documentation

Information in the knowledge acquisition process

Boris Bosancic

Received 2 October 2015
Revised 3 April 2016
Accepted 3 April 2016

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Boris Bosancic
Faculty of Humanities and Social Sciences, University of Osijek, Osijek, Croatia

Abstract

Purpose – The purpose of this paper is to propose an appropriate symbolic representation, as well as its metaphorical interpretation, to illustrate the special role of information in the knowledge acquisition process.

Design/methodology/approach – Besides the literature review, this is a speculative study based on a symbolic and metaphorical point of view.

Findings – The proposed symbolic representation was derived from the conceptual designation of information "as a flow" and, accordingly, by the corresponding redrawing of the data-information-knowledge-wisdom (DIKW) pyramid. The knowledge acquisition process is symbolically represented by the growth of a "tree of knowledge" which is planted on a "data earth," filled with "information sap" and lit by the rays of the "sun of the mind," a new symbol of the concept of wisdom in the DIKW model. As indicated, a key concept of this metaphorical interpretation is the role of "information sap" which rises from the roots of the "tree of knowledge" to the top of the tree and it is recognized as an invisible link between "world of data" and "world of knowledge." This concept is also proposed as a new symbolic representation of the DIKW model.

Originality/value – On the basis of specific symbolic-metaphorical representation, this paper provides a relatively new concept of information which may help bridge observed gaps in the understanding of information in various scientific fields, as well as in its understanding as an objective or subjective phenomenon.

Keywords Information theory, Knowledge, Wisdom, Information, Data, DIKW hierarchy, DIKW model, DIKW pyramid, Knowledge acquisition process

Paper type Conceptual paper

1. Introduction

This paper concisely presents the diversity of views on the concept of information and interprets the process of acquiring scientific knowledge, specifically from a symbolic and metaphorical point of view. In this view, the notion of information takes a central role, in addition to the related concepts of data and knowledge. Indirectly, this paper explores the question of why different perspectives of knowledge acquisition within the scientific fields have different views of information. Two such views, it seems, are directly opposed: one holds information as an objective entity that exists in an "outside world," and a second considers it a construct of our mind.

Therefore, this paper has two aspects: a review aspect and a symbolic-metaphorical aspect. In the first part of the paper, we provide a review. As concisely as possible, we attempt to provide insight into the diversity of views on the concept of information by researchers from various fields of science. These views are considered information theories. We focus on the theory of Claude E. Shannon, directions in the development of other information theories, definitions of information and types of information. The second part of this paper will propose an appropriate symbolic representation as a counterpart to the existing representation of the data-information-knowledge-wisdom (DIKW) hierarchy for the purpose of understanding the relationship between the term "information" and the related concepts of data and knowledge. Through the symbolic

Journal of Documentation
Vol. 72 No. 5, 2016
pp. 930-960

0022-0418
DOI 10.1108/JD-10-2015-0122

representation and metaphorical interpretation, we will try to illustrate the role of information in the process of acquiring knowledge. In this way, we will provide a relatively new understanding of information, which can mitigate, if not completely overcome, the problem of different understandings of this concept in various scientific fields. The symbolic representation and metaphorical interpretation of the role of information in the knowledge acquisition process provides a framework for a new understanding of the observed gap between views of information as an objective or a subjective phenomenon. Such a framework can also be used to overcome this gap.

2. Shannon's theory … and beyond

2.1 Shannon's theory … for the umpteenth time!

As time goes on, there is growing frustration over inadequate and inconsistent understanding of the phenomenon of information in almost all fields of science (Hjørland, 1998; Saracevic, 1999; Cornelius, 2002). This is especially true because it is widely accepted that this is the information age, characterized by widespread use of information and communication technology (ICT). ICT, in turn, is enabled by machine readable, processed information. From Shannon's "information theory," which was released in mid-last century, a similarly revolutionary insight that may stand side by side to his theory, in computer and information science, has not yet been developed. Although "information theory" is not, basically, his original idea and other researchers (Nyquist, 1924; Hartley, 1928) can be thanked for its existence, it contains a key generalization that makes it revolutionary (although mainly in circles of telecommunications and computer specialists, as well as mathematicians, interested in this area)[1]. Time has shown that Shannon's theory made exclusive, revolutionary progress in the field of signal transmission, while the attempt of his colleague Warren Weaver to generalize it into a general theory of communication, at least within the social sciences and humanities, "famously failed" (Machlup and Mansfield, 1983; von Foerster, 1984). Shannon's theory represents a milestone for "[…] the electronic communications networks that now lace the earth" (IEEE Information Theory Society, 2015), according to the Shannon-friendly IEEE Information Theory Society, and digital traffic is measured by bits – units which were introduced by Shannon[2]. However, it seems there is yet no "information theory" that would satisfy all researchers, nor an acceptable definition of information that could be used in all scientific fields.

"How much meaning" was included in Shannon's theory? Shannon claimed "a little." His famous dictum, "[…] the semantic aspects of communication are irrelevant to the engineering aspects" (Shannon and Weaver, 1963, p. 31) could not remove the tension between the two communities. Starting from cybernetics conferences in 1950s[3], it seems that dialogue on the issue of information between researchers from the natural sciences and humanities and researchers from the social sciences to the present day has not achieved significant progress.

To briefly remind ourselves: in Shannon's theory, information is presented by the (logarithmic) coded signals that are managed by the effective probability calculation of their transmission. In short, according to Shannon, information corresponds to yes-no answers to simple questions to select one choice (or message) from a predetermined set of choices (or messages). As in many of these choices, the coding process results in larger code, and hence, a greater amount of information (Shannon and Weaver, 1963). Shannon's colleague W. Weaver explained the essence of "information theory" with the following words: "[…] word […] information relates not so much to what you do say, as to what you could say […]" (Shannon and Weaver, 1963, p. 8). However, Shannon's true contribution to science, as is well-known, was applying probability calculus to the problem of transmission of information. In practice, the choices (messages) from a predetermined set of choices often do not have the same probability value. By example of the letters of the English alphabet as a predetermined set of choices, Shannon showed that the amount of information decreases with the increasing the probability of occurrence of each letter. In this way, he established a strong link between the probability of a certain choice from a set of predetermined choices and the quantity of information generated by that choice (Shannon and Weaver, 1963).

Based on the above consideration, the meaning of the message is not important for "information theory," but only the total number of choices on the basis of which a concrete choice (message) can be unequivocally encoded. In other words, it seems that choices between the options are a function of the transmission of internally coded signals as a carrier of information, not the information itself. Accordingly, the practical value of the inclusion of the probability calculus in "information theory" lies in a precise calculation of the maximum capacity of a communication channel (the maximum possible amount of encoded signals that can be transmitted through these channels per time unit). Or, as Bates (2009) concludes: "Shannon's model of information is dismissed today because he separated information from meaning. What is currently forgotten, however, is that this separation was in fact an achievement" (p. 2350).

So, as regards the practical aspect of Shannon's formula for the amount of information, it was only the calculation of the maximum capacity of a communication channel through which the signals are transmitted. Because of that, meaning in Shannon's paper did not play any role. It was always talking about signal transmission (which, strictly, represents information in an internally coded form), not about the information itself. In his influential book, *Knowledge and Information Flow*, published in 1981, Dretske writes: "It deals with amounts of information – not, except indirectly and by implication, with the information that comes in those amounts" (Dretske, 1981, p. 3), concluding that Shannon's theory may be misnamed. Perhaps it should be called the theory of coding and transmitting information? Similar thinking as this one was offered by other researchers, including Qvortrup (1993) and Bates (2009). However, this opinion is not widely accepted within the scientific community.

2.2 Beyond Shannon's theory … theories, definitions and kinds of information, as well as directions in development of information theory

Many information theories emerged from Shannon's revolutionary paper: Bar-Hillel and Carnap's (1953) "theory of semantic information," "an algorithmic information theory" first proposed by Solomonoff (1960) and further developed independently by Kolmogorov (1965) and Chaitin (1966), a pragmatic "economic theory of information" by Marschak (1954), "a semantic theory of information" first proposed by Dretske (1981) and further developed by Barwise and Seligman (1997) and Barwise and Perry's (1983) situation theory. More recently, additional theories have been developed: Floridi's (2004) "theory of strongly semantic information" (TSSI), Hofkirchner's (2013) framework for "a unified theory of information" (UTI) and, most recently, Mark Burgin's (2010) "general theory of information" (GTI).

In addition to the relatively large number of theories, multiple attempts to more exactly define the phenomenon of information followed. The proposed definitions often included the semantic aspect of information, which is omitted in Shannon's theory. Usually, information was brought into close relationship with another concept; different kinds of conceptual designations/determinations were highlighted in different definitions. Because of the importance of the discussion of the information as objective and subjective phenomenon for this paper, which will be followed in its second part, the conceptual designations/determinations of information are listed in the order from its objective to subjective nature:

- difference ([…] in the sense that makes a difference in the mind) (Bateson, 1969/1972);
- reflected diversity (Ursul, 1971);
- stimuli (Miller, 1968);
- structure (Thompson, 1968);
- patterns ([…] of organization of matter and energy) (Parker, 1974; Bates, 2006);
- thing (Buckland, 1991; Qvortrup, 1993);
- data (well-formed, meaningful and truthful) (Floridi, 2011);
- event (in time and space) (Pratt, 1977);
- process (Buckland, 1991);
- flow (Dretske, 1981; Barwise and Seligman, 1997);
- property ([…] of things to change other things) (Burgin, 2010);
- difference ([…] in mind that finds the difference in nature) (Qvortrup, 1993);
- mental structure (Belkin and Robertson, 1976);
- social construction (the product of social practices) (Cornelius, 1996);
- psychic construction (Qvortrup, 1993);
- cognitive differences (Qvortrup, 1993); and
- knowledge (Buckland, 1991).

In this tentative listing of designations/determinations of information by different authors, of course, a few important things were probably omitted. This applies to what these authors had wanted to point out when they suggested that it would be a good idea for the notion of information to be associated with a particular term. Their ideas, thoroughly reasoned in their papers, require a discussion separate from this paper. After all, at this point of consideration, it seems a good idea to ask the question: how important is it to give a precise definition of a particular term? Capurro and Hjørland (2003) note that it does not matter whether the definitions of terms are true or false (in fact, they cannot be either or both), but whether the theory they support is more or less fruitful. Somehow, researchers are always free to define the theoretical terms as they want, if and only if their theories, in which they would be incorporated, find confirmation in reality.

A solid overview of the definition of information phenomenon was also provided by Case (2007) and Bates (2009). We referred to some of them in the previous paragraph.

It is clear that the aim of this brief review of previous papers about information is only to provide insight into the diversity of views and understandings of this phenomenon, not to serve as a reference for a much more extensive review by other authors like Cornelius (2002), Capurro and Hjørland (2003) and Robinson and Bawden (2012, 2014) and other authors. Nevertheless, it seems that the time has come for the meta-analysis of contributions through the study of the phenomenon of information. One such a paper by Furner (2014), declared as a meta-review paper, observed that papers about information can be divided into three types, based on their objectives (p. 144):

> […] to present and/or to advocate for a single conception of information that was first formulated elsewhere;
>
> – to review and/or to classify a range of existing conceptions of information; and
>
> – to present and/or to advocate for a new conception of information.

Furthermore, each paper may be further categorized depending on whether it is offering "a discipline-independent conception capable of universal application" or "discipline dependent conception intended for application in a context with specifiable boundaries." In addition, Furner proposes that reviews of the concept of information can be distinguished by considering the disciplinary affiliation(s) of their authors. Furner (2014) offers his own meta-analysis of papers about information phenomenon largely based on an ontological view of the information, whose exposure exceeds the limits of this paper (p. 144).

In addition to the relatively large number of papers which contain new or supplement existing information theories, or offer a new or a modified definition of information, a large number of papers were written to categorize the information phenomenon. Floridi (2010), for example, distinguishes mathematical, semantic, physical, biological and economic information. He connects these kinds of information with language and ethics issues. In turn, Burgin (2010) distinguishes information in nature, information in society and technological aspects of information. In this sense, one can speak about objective and subjective information. On the other hand, information can vary according to its use in a variety of disciplines – information in physics, information in psychology, information in biology, etc. (Robinson and Bawden, 2014).

Organizing these papers in an original way, a few prevailing directions of the development of information theory can be seen. Some authors, such as Cornelius (2002) and Wersig (1997), also write of information in this manner. For example, Wersig (1997) considers that one approach to the development of information theory dominated till the 1970s. Wersig characterizes the published review papers on proposed "information theory" and the communication model by Shannon and Weaver. That is the reason why Wersig called this period in the development of information theory the "Shannon and Weaver phase." This phase included, for example, the works of Rapoport (1956) and Brillouin (1956).

In the mid-1970s, in light of the foundation of cognitive science, the information science literature began developing its own approach to the problem of information, known as the cognitive turn or viewpoint. This approach is recognized in papers of Belkin and Robertson (1976), De Mey (1977), Brookes (1980) and other authors. Cornelius (2002) explained this view of information thus: "The critical component in this cognitive viewpoint is that information is mediated by a potential recipient's state of knowledge" (p. 406).

About the same time, the philosopher Fred Dretske claimed that information is relative to what one already knows in general and depends on what one already knows about the alternative possibilities that exist at the source of information. For Dretske (1981), information is just "something that is required for knowledge" (p. 82). However, the author considers information as an objective entity, unlike most information scientists, who claim that information is exclusively a subjective phenomenon.

During the 1980s, the open objectivist approach to information entered the stage and found one of its biggest advocates in biologist Tom Stonier. According to Stonier (1990, p. 21): "Information exists. It does not need to be perceived to exist. It does not need to be understood to exist. It requires no intelligence to interpret it. It does not have to have meaning to exist. It exists." The attitudes of most physicists can surely be counted among an objectivist approach to information. According to physicist John Archibald Wheeler, author of the aphoristic expression "It from bit," matter and energy are carriers of much more abstract and profound entities: information (Greene, 2011).

In response to the objectivist approach to information by researchers who came from the natural sciences, the 1990s saw development of a constructivist approach to information, mainly in the humanities and social sciences. This point of view takes its starting point from several areas of human knowledge (e.g. biology, psychology and sociology). Based on the proposed concept of autopoeises by Chilean biologist's Humberto Maturana and Francisco Varela (1980, 1986)[4], it is reflected, more or less, in the works of N. Luhmann (1990), S. Brier (1992), I. Cornelius (1996) and other authors. Constructivists do not consider information as an objective entity. "Information is an internal change of state, a self-produced aspect of communicative events and not something that exists in the environment of the system and has to be exploited for adaptive or similar purposes," argues Luhmann (1990, p. 10).

The paradox in the development of the objectivist and constructivist approaches to information may reflected by the following fact: the initial trigger for the objectivist approach to information was found in the works of researchers came from the social sciences (Bateson, 1969/1972). On the other hand, the constructivists were inspired by an idea of biologists, researchers who came from the natural sciences (Maturana and Varela, 1980).

As opposed to the constructivist approach to information, pancomputational and paninformational approaches are emerging. According to them, all processes in the world can be reduced to those which have information and a computational nature. Pancomputationalists, like Gregory Chaitin and Gordana Dodig-Crnkovic, believe that nature, in principle, can be understood as a large computer (Chaitin, 2010; Dodig-Crnkovic, 2010). Consideration of information as a purely objective entity seems to culminate in "the world as a hologram" idea by Leonard Susskind (1995). However, this idea is based on "the idea of the holographic principle" by Gerard 't Hooft (1993). According to this theoretical hypothesis only, the whole universe and all events within it are a representation of written information on remote, two-dimensional sheets which light projected into space (Bousso, 2002). The latest research goes so far as some scientists trying to prove the holographic nature of universe experimentally, over the digital nature of space and time[5]. However, no matter how attractive and mathematically consistent this idea is, "the world as a hologram" remains controversial. In this case, the aim was to highlight the role of information in the field outside its usual discussion domain – and not just any field, but physics, perhaps the most fundamental science of all, which, it seems, information wants to crown as "the new queen of reality"!

An effort by philosopher Luciano Floridi to establish a new philosophical discipline, Philosophy of Information, in the 2000s can be viewed as a separate line in the development of information theory. In his book, *The Information: A Very Short Introduction* (Floridi, 2010, p. 9), Floridi writes: "[…] we are not standalone entities, but rather interconnected informational organisms or *inforgs*, sharing with biological agents and engineered artefacts and global environment ultimately made of information, the *infosphere*." Floridi is also one of the researchers who believe that the information is made up of data. According to his TSSI, information is nothing else than well-formed, meaningful and truthful data (Floridi, 2011).

Recently, attempts to shed light on this phenomenon seem to have significantly increased. The World Scientific Series in Information Studies may especially boast of these efforts, announcing in a short time, between 2010 and 2013, three books that follow modern research trends in the field of information theory[6]. It only requires mention of the titles of theories which they are considered to realize the persistence, and perhaps, patience of researchers from different scientific fields to attempt to define information are at their highest point, for example: GTI by mathematician Mark Burgin (2010) or UTI by sociologist Wolfgang Hofkirchner (2013). A little earlier, in 2007, as a part of the edition of the *Handbook of the Philosophy of Science*, proceedings of Philosophy of Information were published by the editors Johan van Benthem and Pieter Adriaans. The proceedings brought into one place eminent authors from different scientific fields, among others, L. Floridi, F. Dretske, K. Devlin and J. MacCarthy (Adriaans and Gabbay, 2008).

In library and information science (LIS), there has also been illumination of this phenomenon. Under the editorship of researchers from LIS, Fidelia Ibekwe-Sanjuan and Thomas M. Dousa, within the Studies in History and Philosophy of Science series, proceedings entitled "Theories of information, communication and knowledge: a multidisciplinary approach" was published (Ibekwe-Sanjuan and Dousa, 2014). Moreover, mentioning Floridi's (2011) General Definition of Information, presented in his book *Philosophy of Information* (in this book the author summarized the ten-year work on the issue of this phenomenon), as well as a book by James Gleick (2011) *The Information: A History, A Theory, A Flood* by the popular-scientific provenance, it becomes clear that information has become a passion of not a small number of researchers today.

Some authors, such as R. Cappuro, came to the conclusion in the 1990s that it might not be possible to build a UTI (Capurro *et al.*, 1997)[7]. Ignorance of information becomes critical, as M. Burgin (2010) said, the more dependent society is on so-called computer processing of information. Is the term information really an elusive concept for any theory? Is it even possible to shed light on it? Or is information simply the sort of thing that one can truly define only ambiguously? However, with due respect to previously proposed theories and definitions of information, a concept of information that adheres to any information theory, from any field of human knowledge, is still lacking. And this work is also a contribution to this effort.

3. The knowledge acquisition process

3.1 "A science is defined by its problem"

By the example of Shannon's theory, it is easy to establish a link between a scientific discovery and its appropriate practical application. A scientific discovery, in this case, the formula for the transmission of "internally coded" information, addresses the problem of its age – the problem of optimal signal transmission. Its solution led to definitions of several closely related terms (information sources, information channels and noise), but not, according to most researchers, to an acceptable definition of information (including C.E. Shannon himself).

If "science is defined by its problems," as claimed by C.S. Peirce (Philosophical Writings of Peirce and Buchler, 1955, p. 66), it might be appropriate to ask ourselves if there is such a problem for information science whose solution, in addition, offers an acceptable definition of information? In theoretical discussions, several problems of information science have been recognized. One of the most important problems of information science recognized by some researchers is the idea of information retrieval (e.g. K. van Rijsbergen, P. Ingeversen, P. Vakkari, etc.). Others have found it in the study of the phenomenon of relevant information (e.g. T. Saračević). For many researchers, the initial problem of information science is information explosion, the phenomenon of an enormous increase of printed publications that began in the nineteenth, but which definitely culminated in the mid-twentieth century.

According to V. Bush (1945), applying ICT was one solution to that problem. However, in the history of science, it is often the case that the solution of one problem in one era becomes a trigger for new problems in a following era. For many, massive ICT use has created a new problem – information flood (Gleick, 2011), characterized by the excessively publication of all types of content in digital form.

However, if attention is drawn to the part of information science where there is a need to define the phenomenon of information "bundled" with the related concepts of data and knowledge, one problem, according to the author of this paper, particularly arises. This is the problem of knowledge acquisition.

3.2 Knowledge acquisition as a problem of information science

The problem of understanding the knowledge acquisition process is primarily one of epistemology or the theory of knowledge, a branch of philosophy, in which the term "knowledge" is its primary focus of study.

Knowledge is a broad and abstract concept. The discussion about its meaning, in the Western philosophical tradition, had already started among philosophers in ancient Greece. The first definition of knowledge as "justified, true belief" goes back to Plato.

Although the concept of knowledge originally belongs to the realm of epistemology, knowledge in the mid-twentieth century, as a result of the development of ICT, began to be seen as the major component of information systems that are focussed on the manipulation of knowledge. Artificial intelligence became the first area of scientific research that tried to incorporate knowledge into expert systems in order to make a computer capable of perceiving and applying it in the same manner as a human does.

Perhaps that is the main reason why today we have two meanings of the term "knowledge acquisition": the first has its origin in philosophy as a "method of learning" proposed by Aristotle, and the second points to the process which takes place in knowledge-based systems. Even so, it seems that in both cases we are dealing with two general types of knowledge: as stated by Capurro in Zins' (2007) research "[…] following Aristotle, we distinguish between 'empirical knowledge' (or 'know-how' 'empeiria') and explicit knowledge (or 'know-that,' for instance, scientific knowledge or 'episteme')."

By the end of the last century, knowledge had begun to be an important organizational resource and had become an integral part of knowledge management (KM) systems. KM is a trend in the modern business world which may be more powerful than all of the previously mentioned areas in disseminating knowledge in modern society. This area of research is especially important because it puts a particular emphasis on the interpretation and development of the DIKW model (hierarchy), that puts knowledge in its proper relationship with other related concepts such as data, information and wisdom, which will be discussed later in this paper.

So, it should be noted that this paper does not intend to treat this problem from philosophical positions and, for example, wondering if any knowledge is possible at all. In addition, our intention is not to consider the problem from a pedagogical point of view, nor from the psychological background of the process. On the contrary, the focus here is on the knowledge acquisition process about the world in general, without having to know if this world really exists or if it is really accessible by our senses. Talk is always about the acquisition of "scientific knowledge," whether it is a subjective or objective phenomenon[8].

On the other hand, it is important to point out that the knowledge acquisition process, as understood in this paper, is only theory-laden, and has nothing to do with any "practical" implication of that term: for example, with a particular scientific method or knowledge-based system. That is, because it seems that it takes place, as it were, at the lowest level of the human (and computer) relationship to reality[9]. I believe that its basis lies in the interaction of related terms – data, information and knowledge – and expect that analysis of this process will discover the acceptable definitions of these terms across all scientific fields. In this way, the nature of knowledge acquisition in all sciences is addressed because all scientists base their research on scientific data, which depends on their knowledge.

Besides Dretske's (1981) approach, in which information is viewed as "something that is required for knowledge" (p. 82), a surprisingly small number of researchers write about this problem. It is worth mentioning the papers by M. MacKay (1969), E. Oeser (1976) according to Capurro and Hjørland (2003) and some Soviet information scientists, for whom only scientific information made sense and whose efforts were summarized by Belkin (1975). In her book, *Big Data, Little Data, No Data*, C. Borgman (2015) approached data exclusively from a scientific point of view. Borgman's (2015) definition of data addresses only scientific data, rejecting any notion of generalization that would be valid for other types of data.

It is also important to point out that in the literature, there are two understandings of information that, at first glance, are incompatible with these proposed definitions. The first is information treated as a physical, objective thing in the world that exists independent of an observer (e.g. Stonier, 1990). The second, information seen as a subjective phenomenon, is dependent on the observer, often attributed the property of "giving a meaning" (e.g. MacKay, 1969). In contrast, the concept of information that is considered here is inseparable from the related concepts of data and knowledge. Hence, in many cases, the terms data and knowledge seem more suitable to those parts of reality which are taken as objective or subjective information first. It is clear that this means that the "objective aspect of information" is somehow correlated with data, and the "subjective aspect," to knowledge.

Ordinary social situations, in which people transmit, receive and generally share information in a broader context, remain aside from this consideration. But, generalization of the proposed framework to all situations should perhaps harmonize the notion of information in a broader context.

4. Bridging the gap in understanding the concept of information: information as a flow

4.1 Is information a subjective or objective phenomenon?

In a paper, "Mind the Gap: Transitions Between Concepts of Information and Varied Domains," L. Robinson and D. Bawden (2014) identify a crucial gap in the understanding of information in various fields of human knowledge by two thoroughly different approaches: on the one hand, information is taken "[…] as something objective, quantitative, and mainly associated with data," and the other "[…] as subjective, qualitative, and mainly associated with knowledge, meaning, and understanding" (Robinson and Bawden, 2014, p. 131). Qvortrup (1993) expressed a similar observation: "At the one end, information may be defined as a thing. At the other end, information may be defined as a psychic construction" (Qvortrup, 1993, p. 3). According to Qvortrup (1993), this dichotomy in the definition of the phenomenon of information leads to the problem of meaning in information theory. On the other hand, Cornelius (2002), on Qvortrup's trail, notes: "It seems accepted that at some point the data by perception, or selection, become information, which feeds and alters knowledge structures in a human recipient" (Cornelius, 2002, p. 394). Cornelius explicitly states that the difference between data and information will not be considered in his paper, because it seems that the relationship between information and knowledge is much more problematic. Qvortrup opposes this position; he drew attention to differentiation and establishing the relationship between data and information. Therefore, it seems that the mentioned review papers on information extraordinarily supplement each other.

One of the most comprehensive reviews of the concept of information was published in ARIST in 2003 by R. Capurro and B. Hjørland. Among other things, these authors distinguish between the objective and subjective aspects of information: "In our view, the most important distinction is that between information as an object or a thing (e.g. number of bits) and information as a subjective concept, information as a sign; that is, as depending on the interpretation of a cognitive agent" (Capurro and Hjørland, 2003, p. 396). According to Capurro and Hjørland (2003), "[…] almost every scientific discipline uses the concept of information within its own context and with regard to specific phenomena" (p. 356). S. Brier (2014) supplements this view by claiming that some of them are rooted in the sciences – some in life sciences, some in the social sciences – and some in the humanities; therefore, they are often incommensurable[10].

However, most researchers managed to establish a consensus on some fundamental properties of information, although it appears that they have not explicitly elaborated within any theory. It was found that information has to be new to the recipient (informative), usually has to be encoded (whether or not this is necessary remains a question), is necessary for knowledge growth, has to be transmitted, and finally, is closely linked to data and knowledge. The last basic property of information will be examined in more detail in the following section.

4.2 Information as a flow … (and previously, as a process)

As a result of the conceptual vagueness that fluctuates between two opposing poles of a fundamental understanding of information – as a thing and as a mental structure – it seems that conceptual-metaphorical designations of information "as a process" (G. Bateson, R. Capurro and M. Buckland) and "as a flow" (F. Dretske, J. Barwise and J. Seligmann) do not belong to any of these mentioned. Moreover, it seems that they can be placed "somewhere" between an objective and a subjective understanding of information. It is hoped that this paper will show that these are concepts can help bridge perceived gaps in understanding information as an objective or a subjective phenomenon[11].

The definition of information as the "difference that makes a difference" (Bateson, 1969/1972) represents a typical example of a definition in which information is realized "as a process." Although "difference" takes causal and consequential roles in this definition – a causal role as a "difference" that occurs in the external world and consequential role as a difference observed by the observing system – the verb "to make" still plays a key role, embodying the procedural nature of information.

Besides Bateson, Capurro (1991, p. 82) takes information "[…] as a more or less adequate metaphor, to every kind of process through which something is being changed or in-formed."

In the literature, a view of information by Michael Buckland (1991) is very often cited, in line with an increasingly frequent understanding of that term "as a process." Buckland notes "three principal uses of the word 'information' ": in addition to information-as-process, which he seems to be closest, information has been identified as a thing (information-as-thing) and as knowledge (information-as-knowledge) (Buckland, 1991). A correct understanding of the concept of information-as-process arises from understanding the specific information action. Buckland thinks that information, by itself, may not even exist; what exists is a process of transmitting it from one place to another, from one individual to another. The literature often cites his statement: "Since information has to do with becoming informed, with the reduction of ignorance and of uncertainty, it is ironic that the term "information" is itself ambiguous and used in different ways" (Buckland, 1991, p. 351).

On the other hand, one of the biggest advocates of the idea of "information flow" was a philosopher, Fred Dretske. He elaborated this idea in his book *Knowledge and Information Flow* in 1981. According to Brier (2014), "Dretske defines information as the content of new, true, meaningful, and understandable knowledge" (p. 29). For Dretske, it seems that information as a flow simply merges into the pool of individual knowledge. However, unlike the point of view by the researchers from LIS, Dretske holds information as an objective, but at the same time, relative phenomenon in relation to the recipient's knowledge (Dretske, 1981). Relativity of information in this case arises from the recipient's knowledge of the situation in which they receive information, not from the knowledge sources or by the information channel through the information arrives to them.

Based on Dretske's idea, Barwise and Perry (1983) have developed a situational information theory. According to this theory, the flow of information is formed depending on the particular type of situation and leads to knowledge growth.

The phrase "information flow" can be found in a book by Jonah Barwise and Jerry Seligman (1997), *Information Flow: The Logic of Distributed Systems*, from that is concerned with the logical formalization of Dretske's approach to information (Burgin, 2010). By all proposed theorems in this book, Barwise and Seligman (1997) have dealt with one issue that had been also troubling Albert Einstein, mostly by the philosophical provenance: "[…] how is it that science, with its use of abstract mathematical models, carries any information at all about the real world?" (p. 174). In an attempt to respond to this question, Barwise and Seligman (1997) reached the phrase of "information flow," which they define as a stream of a binary information channel (C) which connects reality (D) and its idealization in our mind (Q). We think this is an important finding that made an impact on other theories in various fields of human knowledge.

If the specific information action of a specific process is examined, one may ask: what is the "tangible" substance of this process? We believe that the answer to this question can only be: the flow of information. This provides sufficient grounds to reject the conceptual-metaphorical designation of information "as a process" in favor of "flow." Information taken "as a flow" can find a place in almost any of the above-mentioned information theories and trends, with the exception of those in which it has been taken to the extreme, as a purely objective or a subjective phenomenon. Therefore, within the Shannon's theory, the amount of information conveyed through the information channel from the sender to the recipient bears the clear allusions to information understood "as a flow." In the same manner, Qvortrup (1993, p. 5) has talked about information as "water in the water pipe." In cognitive terms, the information is also something which merges into knowledge, allowing its growth. Ultimately, Brookes's (1980) "fundamental equation of information science," although expressed in pseudo-mathematical form, at a conceptual level clearly demonstrates the same thing, including the expression of information as a ΔI (information increment/inflow) in his equation (p. 131)[12].

It is clear that this paper stays close to Shannon's theory. With that choice, the border which separates the objective from the subjective understanding of information is at hand.

4.3 Information as a flow … between data and knowledge!

4.3.1 Information and related concepts of data and knowledge: the unsustainability of DIKW hierarchy. Despite the gap in understanding information in a various scientific fields, it seems that differences in its use are crystallized in common speech in relation to data and knowledge. As in the case of the fundamental properties of information, a consensus on this issue has more or less been achieved, although it appears not to be explicitly elaborated in any theory. For data, colloquial speech says that may be damaged or deleted. That claim will never be made for information; rather, information is vague, ambiguous, or can (not) be accessed. In the same sense, one speaks of having or not having sufficient knowledge to do something. Belkin (1980) claims that knowledge, in its initial form or stage, is always insufficient, as the "anomalous state of knowledge" generates our need for information.

This chapter will examine more closely an intuitive understanding of the relationship between information and related phenomena of data, knowledge and wisdom that has recently been unavoidable in LIS and KM. Understanding of the relationship between those concepts found expression in the symbolic figure of the pyramid (or triangle), known in the literature as the DIKW hierarchy or model. The lower layer is data (largest surface area and volume of the pyramid). The first intermediate layer, above data, is information. The knowledge layer is located above the information layer, while the wisdom layer is located at the top of the pyramid (the minimum area/volume of the pyramid), as shown in Figure 1.

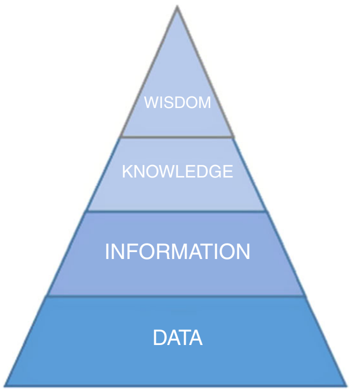

Figure 1.
DIKW hierarchy in its simplest form

This conceptual model was described in the literature by Rowley (2007), Zins (2007), Frické (2008), Ma (2012) in LIS and Zeleny (1987), Ackoff (1989), Liew (2007), Carlisle (2015) and others in the KM field. On the other hand, there is an interesting attempt by N. Sharma (2008) who tried to investigate the origin of the concept of DIKW.

With regard to the concept of the DIKW hierarchy in the field of KM Carlisle (2015) states: "The DIKW hierarchy is a model frequently used in the KM literature to explore the nature of knowledge and, based upon its frequent reference in the KM literature, serves as one theoretical foundation of KM." (Carlisle, 2015, p. 1). There is no doubt that one of the most influential papers in the field of KM, on the topic of DKW hierarchy, is the paper "From Data to Wisdom" by R.L. Ackoff published in 1989. According to Ackoff, the contents of the human mind can be classified into five categories:

(1) data – as symbols that represent the properties of objects and events;
(2) information – processed data; answers questions such as who, what, when, where and how many;
(3) knowledge – answers how-to questions;
(4) understanding – answers why questions; and
(5) wisdom – evaluation of understanding (Ackoff, 1989).

The critical interpretation of Ackoff's view of the DIKW concept can be found in Frické (2008), Ma (2012) and Carlisle (2015). While other KM researchers mostly understand the DIKW hierarchy as a concept which represents the transformation of one concept into another – data into information, information into knowledge, knowledge into wisdom, Ackoff's analysis does not require that approach. "Instead, he states that each category is included in the next" (Carlisle, 2015, p. 2).

Further, for the purposes of this study, attention will be paid only to LIS papers about the DIKW model. A consensus has been reached about the figurative interpretation of the DIKW model in LIS, more or less, as presented in the paper "The wisdom hierarchy: representations of the DIKW hierarchy" by J. Rowley (2007). "There is more data than information, than knowledge, than wisdom. […] The hierarchy with its broad base of data is safe, secure and stable. Wisdom is only attained after much processing of data, information and knowledge, and the process starts with data" states Rowley (2007, p. 175). According to Rowley (2007), the DIKW hierarchy is generally used for the purposes of defining and distinguishing the key concepts of data, information, knowledge and wisdom, while at the same time there is very little discussion about the DIKW concept as a whole.

However, Zins (2007) in his study "Knowledge Map of Information Science" asks whether or not such a viewpoint of the relationship of data, information and knowledge is sustainable. In this study Zins, through the Delphi method, succeeds in documenting 130 definitions of data, information and knowledge by 45 experts from the field of LIS. Zins notes that all three phenomena and concepts undoubtedly correlated with each other, but at the same time concludes that the nature of their relationship is disputed, as is, after all, their meaning. In other words, in many fundamental issues concerning the fundamental concepts of information science, DIKW hierarchy is not helpful in this form (Zins, 2007). The same opinion quotes Cappuro, as a participant of Zins' research; he considered the concepts of data, information, knowledge and wisdom to be irreducible, proclaiming the DIKW hierarchy as a "fairy tale" (Zins, 2007, p. 481).

For Frické (2008) the central point of discussion about the DIKW hierarchy takes up the question of truth. "What the DIKW theorists use, and what is subscribed to in this paper, is the common-sense or objective view of truth." (Frické, 2008, p. 133). He is aware that our knowledge is fallible: in other words, data and information cannot be fully complemented with the request of truthfulness. However, Frické argues that the data "needs to be true." That is because mistaken data is not data at all! It seems that strictness of Frické's approach arises from his reference to operationalism, an approach by which "we could be absolutely certain of what we mean and absolutely certain as to which statements were true" (Frické, 2008, p. 134).

In addition, blind data collection in systems, such as data warehouses, seems to be an inappropriate methodology for Frické. At this point, he refers to Popper's (1963) assertion that belief in collecting pure data without affecting some background theory is absurd.

Finally, Frické proposes abandoning the DIKW hierarchy because of the key logical error at its core. For Frické, the DIKW hierarchy implies that all information arises from data. Nevertheless, there is information that was not previously data. "That the earth rotates on its axis and orbits the sun is information, but not, for most purposes, data" (Frické, 2008, p. 140). This means that information cannot be expressed or inferred from the data that prejudges the DIKW hierarchy. For Frické this is the central logical error of the DIKW model, because the information is generated by the conclusion of first-order logic, and data could be only expressed by the Popper's existential-conjunctive logic, which is at a lower level of abstraction than first-order logic.

Finally, Ma (2012) explores the ontological and epistemological assumptions built into some of the theories in the field of information science including the DIKW model, and concludes that those epistemological assumptions "lead to the negligence of the cultural and social aspects of the constitution of information" (Ma, 2012, p. 716). Nevertheless, with regard to "plurality of meanings or conceptions of information" in these theories (the others are the "Shannon-Weaver model" and "Brooke's interpretation of Poppers World 3"), states Ma, there are equally unfounded epistemological assumptions related to the understanding of human learning and the workings of human minds in a general sense; and also indirectly, in the knowledge acquisition process. Accordingly, the DIKW model commonly represents "the progression of data to wisdom in human minds." However, Ackoff's concept of the DIKW hierarchy is mainly associated with computers, and it is recognized as a data processing model. For the computer, information is perhaps only processed data, but for the human it could be not the case! "Rather, we learn by being situated within and understanding complex webs of relations of persons, events, social and political structures, and many other things." (Ma, 2012, p. 720). Although the DIKW model can be treated by LIS theorists as a basis for a theory of knowledge, relying on the empiricist tradition, which claims that the perception of our senses is a source of human understanding, the DIKW model also remains a "technical metaphor" based on the causal relationship between the involved concepts.

It is obvious that the DIKW hierarchy in this symbolic form of pyramid has proved to be insufficient to describe the many complex relationships of its concepts. I believe that this viewpoint has to be extended, or, more specifically, tailored. This will be done in accordance with the pre-selected conceptual and metaphorical designation of information as flow.

4.3.2 A symbolic and metaphorical view of the DIKW pyramid. According to Capurro and Hjørland (2003), theoretical concepts in scientific discourse "[…] are not true or false elements or glimpses of some element of reality; rather, they are constructions designed to do a job in the best possible way" (p. 344). The same authors also refer to Chalmers (1999), who has noted that Isaac Newton could not give a definition of weight and force in the terms of old scientific vocabulary and was forced to develop new concepts. For Galileo, in turn, Chalmers said: "It is hardly surprising that – contrary to popular myth – his [Galileo's] efforts involved thought experiments, analogies and illustrative metaphors rather than detailed experimentation. This situation is understandable if it is accepted that experimentation can only be carried out if one has a theory capable of yielding predictions in the form of precise observations" (Capurro and Hjørland, 2003, p. 348). Based on Chalmers' considerations, Capurro and Hjørland (2003) proposed "that the scientific definitions of terms like information depend on the roles we give them in our theories" (p. 348).

Because all concepts within the DIKW model are abstract, and intangible in the physical world, J. Hey (2004) believes that it is possible to develop not only a symbolic but also a metaphorical understanding of the DIKW hierarchy. For example, concepts such as "data mining" point to an understanding of the concept of data as hidden, "underground stuff" that needs to be drawn to the surface to become visible and usable, while the term "information explosion" must be understood to mean that information may be out of control at some point in time, disrupt the connections with other things and become something that is hard to find, given that it is scattered in all directions. Literally, data can be subject neither to "mining" nor "digging to the surface" nor information "explosion": these are only metaphors; the algorithms lie behind and manipulate them. However, this metaphorical approach helps to provide an understanding of the nature of the data and information to the human mind in a clearer way than can be achieved in "cold," abstract definitions.

The theory of metaphor appeared in the 1980s in the areas of cognitive linguistics, and is linked to the works of Lakoff and Johnson (1980), Fauconnier and Turner (2002), Brown (2003), Gibbs (2008) and others. Lakoff and Johnson (2003) state, in the book *Metaphors We Live By*: "[…] any human conceptual system is mostly metaphorical in nature" (p. 185). The truth exists, but it is relative to our conceptual system. Lakoff and Johnson hardly criticize the exclusiveness of objectivism and subjectivism, considering both as myths. There is neither absolute objectivity nor absolute subjectivity; there can be only "a kind of objectivity relative to the conceptual system of a culture." According to authors, metaphor is a key conceptual tool for that view of reality because it unites reason and imagination. "Metaphor is thus imaginative rationality" (Lakoff and Johnson, 2003, p. 193).

Among those already mentioned, "data mining" and "information explosion," LIS has numerous other metaphors in common use: Bates' (1989) Berrypicking, Chatman's (1991) Small Worlds, Dervin's (1998) SenseMaking, Information Grounds by Fisher *et al.* (2004) and so on.

"There is a clear-cut test for distinguishing a metaphor from a symbol" states Eco (1984, p. 141): while metaphor allows that allegorical meaning completely replaces the literal meaning, a symbol retains its original meaning even in those cases when a metaphorical meaning is central (Eco, 1984; Nöth, 2004, p. 182). So, the symbol of the pyramid or a triangle, therefore, will retain its original meaning after the meaning of the concepts of DIKW are transferred to it. But, what exactly does the DIKW pyramid symbolize? If one says: "the relations of DIKW concepts," this does not seem to be enough. Does the DIKW pyramid symbolize a knowledge acquisition process? This symbol could be truth. But, in that case, the DIKW pyramid would seem to be composed of "bad" metaphors. Because of its static nature, "pyramid building layers" of data, information, knowledge and wisdom seem not be able to represent the dynamic nature of such a process as a knowledge acquisition process. That provides another reason for abandoning the DIKW model in the form of a pyramid. In the next chapter, we will go further in attempting to redraw the existing DIKW model in accordance with the pre-selected conceptual designation of information as a flow.

4.3.3 Redrawing of DIKW hierarchy. In accordance with what has been said in a previous chapter, attention now turns to the design of a new symbolic representation of the DIKW model but with a new instructional statement: the information will be taken "as a flow" at the conceptual level. Bearing that in mind the information layer of the DIKW pyramid took the form of the channel through which information "flows" from the "data layer" toward the "knowledge layer," and vice versa. This yields a new symbolic representation of the DIKW hierarchy, shown in Figure 2.

In a figurative sense, it is obvious that this is not a pyramid anymore, other than the glimpse that rather reminds one of a tree, with a "knowledge tree crown" and "information trunk," which relies on a "data ground." For simplicity, this picture is, temporarily, called the DIKW tree. As it is immediately evident, the "wisdom layer" lost its "material embodiment"; it is represented only by the rays of the "sun of the mind," which is a new element of the symbolic representation of DIKW relations. In this sense, it is easy to establish an analogy between the light and the heat of the sun and the growth of an ordinary tree, on the one hand, with the rays of the "sun of the mind" and growth of the "crown of the DIKW Tree," on the other. Accordingly, it can be said that the rays of the "sun of the mind" symbolize the human faculty for abstract thought or, in broader sense, the universal intelligence, which is necessary for the adoption and organization of knowledge.

In our opinion, this new symbolic representation of the DIKW model, i.e. the DIKW tree, much better symbolizes the knowledge acquisition process than the DIKW pyramid. The DIKW tree, as a symbol of knowledge acquisition process, is at the same time also a metaphor. Figurative statements such as "knowledge is growing," "knowledge is branching" are conceptual metaphors in the conceptual background of the DIKW tree. The DIKW tree further consists of other metaphors: "data ground," "information sap" and finally – the rays of the "sun of the mind"[13].

Furthermore, if the DIKW pyramid equally emphasized the structural and partly functional aspects of DIKW relationships, this concept of the DIKW tree particularly emphasizes its functional aspect. The functional aspect is reflected in the prominent functional roles of each constituent of the DIKW tree. For example, the function of "information sap" is passing the "data nutrients" from "data ground" to the "knowledge tree crown." The function of "data ground" is as the source of "data nutrients" that are

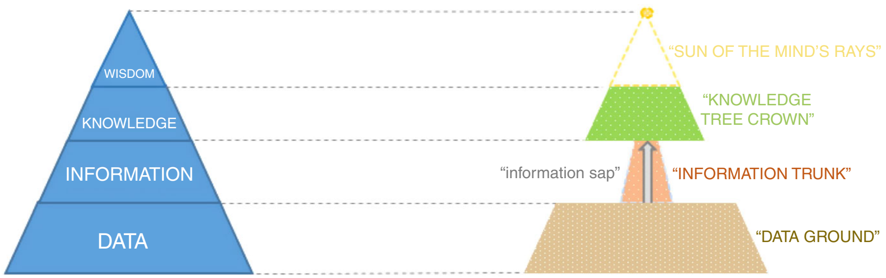

Figure 2. "The DIKW Tree" – a new symbol of data, information, knowledge and wisdom relations, developed by the simple redrawing of the DIKW pyramid

necessary to the growth of the DIKW tree. Finally, the function of "knowledge tree crown" could have several functions: transmitting "information sap" through the branches, converting it into "solidified knowledge," receiving into its leaves the rays of the "sun of the mind" and so on.

The central difference between the DIKW pyramid and the DIKW tree is that functional aspects are much better supported by the DIKW tree. The static nature of the DIKW pyramid has been replaced by the dynamic nature of the DIKW tree. Furthermore; we believe that a new symbolic representation of data, information, knowledge and wisdom relationships could resolve the aforementioned counterarguments in a much better manner than the DIKW hierarchy by Frické, Ma, Capurro and other authors. Further explanation of this reasoning follows in the remainder of the paper.

Now, if information, in accordance with its designation of "flow," is understood as some sort of sap which runs throughout the tree, from the roots to the tree crown and back, it is clear that trunk of the "DIKW Tree" has no longer an informational character. By its composition, it seems that is far closer to the tree crown or roots of the "DIKW Tree" than to the "information sap" or "data ground." In other words, no obstacle is seen in the fact that all tangible, solid parts of the tree (a crown, a trunk and roots) are understood as a whole of actual, controlled, comprehensive knowledge which was previously grown. On the basis of this conclusion, a new name is suggested for the symbolic image of the "DIKW tree" in the context of "data ground," where it is growing, and "information sap," with which it is filled; it is a "tree of knowledge."

5. "Tree of knowledge": a symbolic representation and metaphorical interpretation of the knowledge acquisition process

5.1 Previous meaning of the term "tree of knowledge"

Colloquial speech also often represents the knowledge concept by the tree symbol. In Croatia, to all school children, "lovers of science," there is a well-known magazine named *Knowledge Tree*. On Wikipedia, the phrase "tree of knowledge" refers to several meanings. Undoubtedly, the most famous is the one that refers to the "Tree of Knowledge of Good and Evil." The concept of "tree of knowledge," in the sense in which it is used in this paper, probably has its origin in Ramon LLull's work "Tree of science" from the thirteenth century. In addition to Biblical references and Llull's work, other uses of that phrase, including mention of the Croatian magazine, are related mainly to published books and films[14].

The most comprehensive history of the concept of the tree diagram illustrations for representing data, information and knowledge may be found in the book *The Book of Trees: Visualizing Branches of Knowledge* by Manuel Lima (2014). As Jonathan Keats (2014) states: "[…] as Lima's book shows, the greatest impact of trees was in the realm of taxonomy, as visual representations of abstract religious and scientific concepts."

Indeed, in countless cases, knowledge is "something that has grown," and which can be renewed, but also which can "dry up." "The ground" in which the "tree of knowledge" is planted, in an appropriate analogy, could be seen as "data ground." It is lit by the "rays" of the "sun of the mind" whose impact on the its growth is not negligible. And, what largely nourishes the "tree of knowledge" that grows on the "data ground," is "information sap," which simply rises from its roots to the top of the tree! This is, of course, too simplistic an image, but it will serve as the basis for making the image of the "tree of knowledge" more explicit below.

5.2 The symbolic description of the "tree of knowledge"

Figure 3 shows the deployment of scientific fields in the "knowledge tree crown," accentuating their position on the boundary constituents of this symbolic representation – "data ground" and "sun of the mind." Thus, natural and technical sciences are deployed at the bottom of the "knowledge tree crown," nearest to the "data ground," symbolizing their relatively straightforward access to data from the "outside world," as opposed to other sciences. They are not interested much in what is going on above them. You can imagine that each branch of the tree crown in "the area of natural and technical sciences" belongs to one discipline which further forks into other branches, its subdisciplines, etc.

In the middle of the tree the social sciences are settled, in a very different environment than the natural and technical sciences. It interprets all relations in the world on the basis of the "information sap" running throughout the tree crown. This situation cannot be different, just because of their position within "tree of knowledge"; social sciences can only "feel" the other branches and leaves of the DIKW tree. One can imagine that each branch of the tree crown represents a social and humanities discipline and every twig its subdisciplines. Going even further, each leaf on the branch may represent, in a metaphorical sense, a scientific theory and so on.

Along the edge of the "tree of knowledge" crown, the humanities are deployed. It is obvious that "sun of the mind" sends most of its rays to them. This point suggests an important conclusion: beside the "information sap" which is coming from "data ground," the growth of the "tree of knowledge" crown is also undeniably affected by the "rays" of the "sun of the mind" above it.

As we can see (Figure 3), the "tree of knowledge" trunk can be viewed as a major transmitter of information and may symbolize a knowledge about ICT in general.

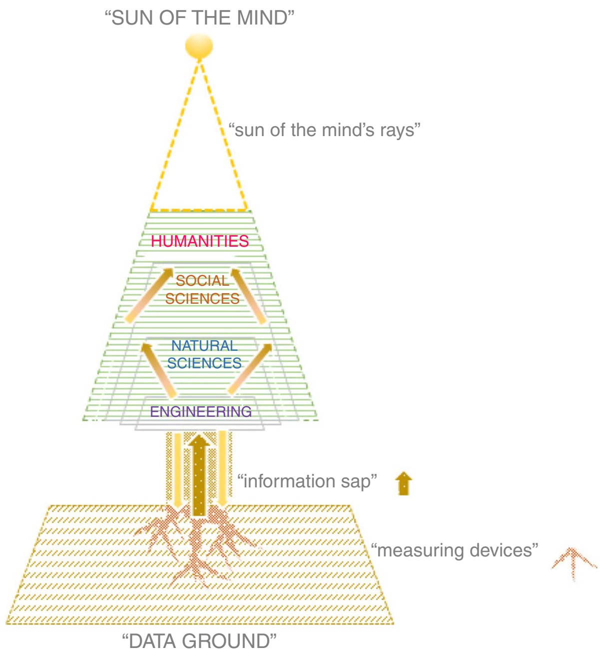

Figure 3. "Tree of knowledge" – a symbolic representation of the different perspectives (scientific fields) of knowledge acquisition

In terms of natural and technical sciences, nothing prevents that, except the tree crown, other parts of the tree, such as tree trunk and even roots also proclaim their knowledge. Surely, a strict distinction here is not necessary, as long as one points out only the differences between the positions of natural and technical sciences and humanities and social sciences in the context of the "tree of knowledge."

Below the tree trunk, and already immersed in "data ground," lies the "tree of knowledge" roots, which mainly symbolize the measuring devices and other tools used to retrieve data in each field of science. Of course, the most common devices belong to the researchers from the natural sciences. In addition, the roots of the "tree of knowledge" can symbolize knowledge about particular methods and techniques that are used to retrieve data in each field of science.

5.3 Some objections to symbolic description of "tree of knowledge"

However, at this point, at least two objections can be already made to our symbolic description of the "tree of knowledge." The first objection concerns the apparent discrepancies between an information property that it has no effects on the data structure from which it is extracted and the analogue property of "information sap" required to really take "data nutrients" from the "data ground." The second objection is related to the vague way in which researchers from the social sciences and humanities access to data; for example, how could one present a book as a source of information by such a conception?

Regarding the first objection, it is clear that "information sap" has to be such that its extraction from the "data ground" does not violate the data structures. It is obvious that the letters remain in a book and after they are read. Hence, it is clear that "information sap" is not and cannot be a "sap" in the normal sense of that word, as found in an ordinary tree (such a "tree of knowledge" is not usually a tree that can be found in nature). By all means, its composition and, thus, nature are specific. If it is nothing taken by the process of extraction from "data ground," the only acceptable solution is to imagine that "information sap" is created by mapping "data components" from "data ground," which at a given moment, had been lying on the tops of the "tree of knowledge" roots. In this way, one can think about "information sap" as some sort of electromagnetic phenomenon (nonetheless, in a real or figurative sense)[15].

Regarding the second objection, it appears that neither the retrieval method nor the data storage location of the data are understandable by social sciences and humanities researchers, at first glance. Perhaps it is "buried" in the "data ground," together with natural sciences researchers' data? Perhaps it is coming from root branches or tree branches of another "tree of knowledge" close by?

Apart from these possibilities, the image of the "tree of knowledge" offers still another possibility: the research data of the social sciences and humanities can be easily taken as knowledge of other researchers which flows from other branches via the "information sap." This paper insists precisely on this last meaning. However, to understand this point of view, the reader must use great power of abstraction in imagining. You can imagine that "information sap," immediately after its creation, comes into contact with the existing "solidified knowledge" of the "tree of knowledge." Because the process of mapping must continue to take place within channel walls, there is some sort of "infecting" of "information sap" by existing knowledge. This "infection" already takes place in the root of the tree. We can easily say that existing knowledge of methods and techniques, via which "data nutrients" are retrieved from "data ground," is also mapped into "information sap," together with the source "data nutrients." In some respects, the "nutrients of existing knowledge," on which the scientific research data greatly depend, offer the metaphor of Kuhn's concept of scientific paradigm, which he mentioned in his influential book, *The Structure of Scientific Revolution* (Kuhn, 1962/2012). In the same way, for Popper (1963) "the belief that we can start with pure observations alone, without anything in the nature of a theory, is absurd" (p. 46). In other words, it is very true that all data are theory-laden (Zins, 2007). In general terms, existing knowledge can simply be realized as the literal knowledge of previous researchers. This means that the "infection" of "information sap" by the existing knowledge happens "even" to researchers from the natural sciences. This is logical, because the context of their own research forces them to rely on the knowledge of their predecessors. However, the effect of "infection," definitely, is the most intense in the crown of the "tree of knowledge," where "information sap" is exposed to far more influence by the surrounding knowledge. In an extreme case, one can imagine that the "information sap" is composed almost entirely of mapped "knowledge nutrients." The remaining source data nutrients could be applied only to the storage medium of that knowledge. (This could be a book, but also a computer screen.) That is exactly the case; research data from the social sciences and humanities can be recognized mostly in the existing knowledge of their predecessors[16]. This concept also provides the solutions for most of Fricke's counterarguments against the DIKW model.

It would be very interesting how this understanding of the nature of data, information and knowledge could be applied to realizing the process of receiving information from the computer. Here, it is extremely important to realize how all content stored on computer memory units is, in fact, its "knowledge," although it is pure data. In this case, a memory unit is a "computer head." A computer also retrieves its source data exclusively from the "outside world." However, what a computer is missing in the knowledge acquisition process is the much wiser "sun of the mind." In other words, it is missing artificial intelligence, which is more effective in organizing knowledge intelligently; among other things, this is the main reason why computer "knowledge" is "seen" today as only data[17].

By this symbolic picture, it is also necessary to clarify and try to imagine the case of representation and data access from questionnaires. It is important to emphasize that it is obviously "source data," and not some sort of existing knowledge. Accordingly, a "tree of knowledge" picture suggests that they must be located in the "data ground." However, it is obvious that you cannot find them there, because the "data ground" represents only data from the "outside world." When you think about it, you may only come to the conclusion that their source must lie somewhere above "data ground" in an area on which the "sun of the mind" shines. That is, it because filling out the questionnaire puts actual human consciousness out of action, which produces pure data about itself and its views about the "outside world." That is a reason why the origin of this kind of data must lie somewhere above the "data ground." In addition, the impact of our current mood in the process of filling out the questionnaire should not be forgotten. One may recognize the symbol of this impact in an atmosphere that reigns above the "data ground."

In a broader sense, the nutrients of the atmosphere that surrounds the "tree of knowledge" represent, as a whole, human consciousness. Many of those "atmospheric nutrients" set down to the ground; some of them can be recognized as source data from questionnaires. In the form of "air pockets," they could penetrate deep into the ground, where a root branch of the tree could extract them and convert into "information sap." These are, perhaps, fragments of human consciousness that produce data on the basis of what they "know" in a particular moment. But they can also be bits of consciousness not directly linked with personal knowledge, referring to data based on what one fragment of consciousness feels or has experienced. In both cases, one consciousness can give answers to the questionnaire, which can be regarded as sufficient research data for the social sciences.

In this way, one may conclude that a new symbolic representation of DIKW relations, at this level of interpretation, can differentiate at least three types of data: source data, which was retrieved at the tips of the tree roots (and which belong exclusively to the "outside world"), "data of existing knowledge," mainly stored in the tree branches, and "data of atmospheric nutrients," which may be set down to the ground and extracted to "information sap" by the appropriate root branches of the "tree of knowledge."

This way of understanding data agrees very much with our experience in the real world! Knowledge of an individual, informed by conversation with them, before it establishes itself as personal knowledge of our own and not necessarily equally (because of the noise of the information channel), at least, at the beginning of the conversation, in a short period of time and in its original form, represents only data[18]. In addition, this symbolism and associated metaphorical processes seem much closer to Ma's understanding of human learning and the workings of human minds (Ma, 2012).

5.4 Bridging the gap in understanding information as an objective and subjective phenomenon

Does a new symbolical representation of the knowledge acquisition process help bridge the gap in understanding information as an objective and subjective phenomenon?

To determine, in a given symbolic sense, the possible reason for a different view of information from various scientific fields, it will be considered how the scientific fields from their position or perspective in the "tree of knowledge" image experience "information sap" or information. As an example, the growth of knowledge of researchers from the natural and social sciences will be compared. Because of the fact that they are mostly considering information as objective phenomenon, natural sciences and engineering are symbolic positioned immediately at the bottom of the crown of the "tree of knowledge." That is, because the natural sciences and engineering researchers' knowledge is built on the basis of what it has taken directly from the "data ground" by experimental observation. For researchers from the natural sciences, "data ground" is the "outside world." From this perspective, "information sap" or information itself must appear objective, as something that is literally taken from reality and has changed its form only inside the "tree of knowledge."

If a researcher from the natural sciences wanted to establish a particular "law" of "information sap flow," this "law" would largely depend on its position at below the crown of the "tree of knowledge." In its "formula" (or "definition"), it would include factors prevailing at the root and the trunk of the tree which are most accessible to them. For example, the composition of "data nutrients" or the effect of its "infection" by existing "solidified knowledge" (as referred to in the previous section) and so on. This leads to the conclusion that the "information sap," or the information itself, is only a "data vehicle," something that must be objective.

On the other hand, the knowledge of researchers from the social sciences, symbolized by the branches and twigs in the crown of the tree, is primarily based on information that comes from the local branch and was reduced to a reinterpretation of the knowledge of other researchers in their scientific fields. Some of the source data flows from the "data ground," but following the discussion in the previous section, most of it originates from other branches. If a researcher from the social sciences would like to establish their own "information sap law" of some sort, the calculation will not coincide with that by a researcher from the natural sciences. In his "formula" (or "definition"), a hundred "different" forks must be included that dominate the interior of the tree crown. From his point of view, the law of "information sap" flow largely depends on the structure of the tree crown, rather than on what he originally carried – some sort of space-time message from the ground or the surrounding atmosphere. This leads to the conclusion that the "information sap," or the information itself, is only a communication tool, a "social construct" of all branches in the region – in other words, something that is subjective.

Of course, it does not matter which factors enter into the so-called "calculation" of researchers from the natural and social sciences. All of these are only metaphors, symbols. It is only important to note that, whatever they may be, in the context of the "tree of knowledge," they must vary considerably, relative to one another, with respect to the position they occupy in the given picture. In other words, differences in the interpretation of the nature of "information sap" that circulates through the "tree of knowledge" are in a function of the position of the individual branch or another part of the "tree of knowledge," which measure and interpret.

On the other hand, with a focus solely on information in a metaphorical interpretation, the flow of "information sap," can be viewed as occurring only within the "tree of knowledge." As such, the "information sap," or information itself, is a completely subjective phenomenon, since the "tree of knowledge is entirely "stretched" in our mind. On the other hand, it is evident that "information sap" contains the mapping "data nutrients" from the "external reality." It still cannot be said how those nutrients are incurred. Thus, in the proposed symbolism, information is subjective, because it is "visible" within the "tree of knowledge." But at the same time, the information is objective, because it contains "data nutrients," which have an objective origin! They originate from the "data ground," which undoubtedly belongs to the "outside world."

Of course, this description offers many more possibilities for symbolic and metaphorical interpretation, but there is a danger that this discussion could go too far. So we can only allow it in part in the conclusion[19].

6. Conclusion

The purpose of this conceptual and yet speculative study was to examine the role of information as a "flow" in the context of the knowledge acquisition process. In so doing, the knowledge acquisition process was itself symbolized by the image of the "tree of knowledge" and interpreted by the following metaphors: "information is sap," "data is ground," "knowledge is tree" and "wisdom is the sun's rays." At the same time, this arrangement is advanced as a new symbolic representation of the DIKW hierarchy. It is proposed that these considerations at least enable understanding of the diversity of views about information within the various scientific fields. As has been shown, differences in the interpretation of the nature of "information sap" that circulates through the "tree of knowledge" is a function of the position of the individual branch or another part of the "tree of knowledge," whose goal is to measure and interpret as well as to represent a particular scientific field symbolically. These differences also throw new light on the observed gap in the perception of information as an objective and subjective phenomenon, in the direction that must be overcome. In the proposed symbolism, information is subjective, because it is "visible" within the "tree of knowledge." But at the same time, the information is objective, because it contains "data nutrients," which have an objective origin! Further, this opens the way for a particular symbolic perspective on the further metaphorical interpretation and implications of the proposed model.

The “data ground,” in which the “tree of knowledge” is planted, represents a symbol of retrieval and measurable “outside world,” in an excrete measurable data. Meanwhile, the crown of “the tree of knowledge” may represent a symbol of explicit knowledge about the “outside world.” I have also proposed that the trunk of the “tree of knowledge” can symbolize a major transmitter of information. In addition, the roots of the “tree of knowledge” can represent the symbols of measuring instruments, devices, tools and different methods and techniques for retrieving data from the “outside world.” Finally, any “solid” part of the “tree of knowledge” may symbolize certain knowledge, including those belonging to its trunk and roots.

According to the proposed symbolic representation of the knowledge acquisition process, based on the growth of the “tree of knowledge,” information is recognized as a subjective but impersonal, meaningless, mapped and encoded flow (because it always transmits somewhere), an invisible “communication tool” between data and knowledge. The role of information as an invisible link between two worlds, the “world of data” and the “world of knowledge,” might be not an overly original idea, but this paper holds that the idea is significantly deepened.

On the other hand, both of the processes – the process of “data nutrients” excretion and the process of “information sap” creation – inevitably remind one to the processes of coding and selection of one choice (message) from a given set of choices in Shannon’s theory. But is it really possible to take these processes as a metaphor of processes which are the backbone of “information theory?” This remains for discussion. If these opportunities are accepted in the context of this particular symbolic image, Shannon’s theory would be then “located” at the very tips of the “tree of knowledge” roots. In addition, these considerations produce a dramatic “insight”: the knowledge acquisition process is in this way based on some kind of “(en)coded reality” (which refers to the secretion of “data nutrients” from the “tree”), and consequently on its perception and transmission (which refers to the processes of “information sap” creation and its raising to the crown of the tree): all this in order to increase overall knowledge in general[20].

One of the major implications of this symbolic representation of the knowledge acquisition process is another flow which might take place throughout the “tree of knowledge.” This flow is driven by the rays of the “sun of the mind” and is carried out in the leaves of the “tree of knowledge.” It moves in the opposite direction to “information flow” and could symbolize the major impact of our abstract thought or universal intelligence on the knowledge acquisition process in general. Since this flow may be drawn down to the roots of the tree, we propose to call it “meaning sap.” It is apparent that this imagery clearly implies that the ability to obtain “data extraction” from the “outside world” does not prejudge the meaning of these concepts. Shannon’s theory is widely recognized as a valid information theory, but a theory which represents only one building block of a much broader theory of knowledge. This theory can no longer be considered separately from the concepts of knowledge and meaning in the context of the knowledge acquisition process. Consequently, it seems that “tree of knowledge” could represent even this broader theory, if it takes “meaning sap” into consideration as well. But this metaphorical interpretation should perhaps be left for further discussion.

Perhaps the most impressive contribution of the proposed symbolic representation is the “visibility” of information itself. Within a process of acquiring knowledge in the real world, the information will always remain hidden, as well as its meaning. In the real world, what is visible always refers to data. At the same time, knowledge is “felt,” in some way, in the head. Hence, information not only appears as the value of this process, as concluded by Losee (1997), but it can also be taken as one of its parts. The fluidity of "information sap," which contains (en)coded "data nutrients," represents an important, but beyond the given symbolism, so far an unknown property of information which may refer to its procedural nature.

Information by itself has no meaning, but only with meaning can it be perceived and understood. This apparent contradiction seems to disappear once data, information and knowledge are examined through the perspective of one primary, higher level phenomenon. However, the elaboration of this idea will be left for further reflection. Such reflection must rise above the restrictive, symbolic framework and offer new, entirely scientifically based views on information.

Notes

1. Hartley (1928), on the trail of work by Nyquist (1924), calculates a measure for the amount of information as the logarithm of the total number of possibilities of occurrence of an arbitrary string of symbols. This is expressed by the formula: $H = \log s$. Shannon's key generalizations consist of the probabilities in this equation. To be precise, the probability of a specific symbol in an observed sequence is calculated based on the equation for the amount of information. The final, generalized expression is: $H = -K \Sigma p_i \log p_i$.
2. Although Shannon is not the author of the mentioned neologism, according to Shannon, it was created by J.W. Tukey (Shannon and Weaver, 1963, p. 32).
3. As J. Gleick stated in his book (Gleick, 2011), it was the meetings sponsored by Frank Fremont-Smith and the Josiah Macy, Foundation that encouraged debate among experts in different scientific fields. Their conference on cybernetics, moderated by neurophysiologist W. McCulloch, was devoted to consideration of what, at that time, information and communication technology brought, as well as its prominence part – "information theory." In addition to Claude E. Shannon, Norbert Wiener, John von Neumann, Heinz von Foerster and others who represented researchers from the natural sciences and engineering, the meetings were attended by Donald M. MacKay, Gregory Bateson, Margaret Mead and other researchers from the social sciences and humanities.
4. A short overview of the work of biologists H. Maturana and F. Varela is given by L. Qvortrup (1993): "[…] according to Maturana and Varela, information is not a "thing" or "substance" in an observed system. First, […] the autopoietic system is a closed system. Second, [the autopoietic system] is a self-reference: the components must "realize" the network that produced them." To explain how one autopoietic system affects others, Qvortrup reaches for a quote from the paper by the biologists: "[…] the autopoietic conduct of an organism A becomes a source of deformation for an organism B, and the compensatory behaviour of organism B acts, in turn, as a source of deformation of organism A […]" (Maturana and Varela, 1980, p. 120) in Qvortrup (1993).
5. Accordingly, a theoretical physicist Craig Hogan at the Fermilab in the USA is building the detector on the principle of the interferometer. It should detect a slight tremor of space on the level of the Planck distance (1.616252×10^{-35} m). If these tremors make a confirmation in practice, Hogan claims it would make sense to talk about space as built by discrete, quantized units – bits of information (Moyer, 2014).
6. These are the following books: *Theory of Information – Fundamentality, Diversity and Unification* by the mathematician M. Burgin, published in 2010, in which author proposes his own general theory of information (GTI); *Information and Computation – Essays on Scientific and Philosophical, Understanding of Foundations of Information and Computation*", a collection of papers that have been edited by Gordana Dodig-Crnkovic

and Mark Burgin; and *Emergent Information – A Unified Theory of Information Framework*" by Wolfgang Hofkirchner, published in 2013, in which the author considered a unified theory of information (UTI).

7. According to Capurro's trilemma (Capurro *et al.*, 1997), information can mean: anything equally at all levels (univocity); something similar at all levels (analogy); and something different at different levels (equivocity). Therefore, Capurro concluded that this is a concept with incredibly wide meaning, elusive for any theory.
8. For example, realizing knowledge as an objective phenomenon is attributed to the Austrian philosopher Karl Popper and his concept of "three worlds." Often cited in the literature, Popper's idea of simultaneous existence of three worlds is related to: the physical world (World 1), the world of mental states (World 2) and the so-called Popper's third world – the world of objective knowledge or intellectual content of human thought (World 3). All that mankind ever spiritually created falls into Popper's third world, that is, scientific, artistic and literary works, as well as texts of religious traditions. According to Popper, there is no difference between information and knowledge – that is all "logical content" that belongs to World 3.
9. In this sense, scientific knowledge cannot be limited to "human scientific knowledge." This is a logical conclusion because the knowledge acquisition process is a process which is not restricted by being able to take place only in human minds.
10. In his paper, Søren Brier (2014) aims to produce a transdisciplinary framework that allows interdisciplinary connections between information and related terms under the patronage of a relatively new discipline – cybersemiotics. The result is represented by the Cybersemiotic Star, which includes a fourth world and four different types of research topics: the three top stars, more or less, coincide with Popper's idea of three worlds, while the fourth star relates to the world of living organisms, which Popper might easily rank in the world of physical things. Brier (2014) says: "As a consequence of the widely shared perspective that human beings are embodied, feeling, knowing, and enculturated beings participating in semiosis and language processes, our analysis so far points to the fact that they can be seen as living simultaneously in four different worlds" (p. 37).
11. The concept of information being developed as a part of the unified theory of information also has the ambition to bridge the definitional dichotomy, but by completely different theoretical assumptions (Hofkirchner, 2013).
12. Brookes' (1980) "fundamental equation of information science" has the form: $K(S)+\Delta I=K(S+\Delta S)$. It can be interpreted as follows: knowledge structure $K(S)$ changes with each new information inflow ΔI.
13. The coining of the "sun of the mind" metaphor is inspired by "the intelligible sun" metaphor which was first mentioned by the French philosopher Jacques Derrida in an essay "Violence and Metaphysics" in his book *Writing and Difference*, first published in 1967 (Derrida, 2005, p. 112).
14. Among publications that have the "tree of knowledge" phrase in their titles are the novel by Pio Baroja, the book by Marshall Cavendish and the book *The Tree of Knowledge: The Biological Roots of Human Understanding* by Chilean biologists Humberto Maturana and Francisco Varela, previously mentioned in this paper. There are also the silent film by William Cecile de Mill and drama by Danish director Nils Malmros.
15. It is interesting that the flow of information can also be understood as an electromagnetic phenomenon. On that way, it may be speculated the possible ways of leaving this symbolic perspective, but that possibility will not be considered further in this paper.
16. There is a possibility that the "tree of knowledge" is entirely realized as Popper's World 3. This would also mean giving up the clear distinction between data as "recorded knowledge" and as a pure knowledge in the researcher's head, which was preferred by Popper. In this

case, "data ground" can be considered as Popper's World 1 (the world of physical things) and the atmosphere, in which the "tree of knowledge" is growing, as his World 2 (the world of mental states).

17. Of course, in this way the concept of data are relativized, making it much more like the concept of information.

18. In the same way, one can view "genetic information" as representing data coded by the connections among amino acids in DNA. When RNA was "informed" about these connections it acquires a knowledge, how to managing the construction of living cells.

19. This was the case in a draft version of this paper. But, according to a comment by one referee of the paper: "[…] when many metaphors are mentioned one after the other, there is a feeling that the metaphor itself becomes a clumsy apparatus." After further consideration, I strongly agree, so I have abandoned the idea of further symbolic and metaphorical interpretation. I am thankful to both of the reviewers because they have pointed this fact out to me in their own ways. But, if you let me, I will try shortly to show one typical example of such reasoning. To find the answer to the question how, "information sap" rises in the "tree of knowledge" for example, the processes of "osmosis and 'transpiration" could be investigated by use of further metaphorical interpretation. In fact, biology has no clear answer to which way the water and nutrients reach the crown of the tree. According to some opinions, the osmotic pressure, which comes from the ground, allows the transmission of water and nutrients vertically through the cell's membrane. According to others, the process of transpiration or water evaporation from the leaves is responsible for this. That could bring one to the following insights: if we believe that our idea of the "outside world" is influenced by "osmotic pressure" from "data ground", then our position closely relates to the objectivist approach to information, such as Stonier's approach. On the contrary, if the heat of the "sun of the mind", which evaporates the water from the leaves, is mainly responsible for the "information sap" rising in the "tree of knowledge", then this position is relatively close to the constructivist approach to information, for instance Luhmann's approach to information.

20. According to Weaver's interpretation, "information theory" is more associated with "what could you say" than with "what you said." The "data ground" might be seen as the total number of possibilities of "external reality" in the form of "data nutrients" that can be excreted on the tips of the "tree of knowledge" roots. This includes "information sap." In this manner, truly provocative questions can be asked: does the overall set of "outside world" possibilities really fit the space-time reality? Does its coding really suit our mathematical methods (geometry, algebra, etc.), which are used to retrieve it? The answers to these questions are left for further discussion.

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Corresponding author
Boris Bosancic can be contacted at: bbosancic@ffos.hr