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ZASTOSOWANIA INFORMATYKI W NAUCE, TECHNICE I ZARZĄDZANIU

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Książka wydana dzięki dotacji KOMITETU BADAŃ NAUKOWYCH

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KNOWLEDGE MANAGEMENT IN LIGHT OF THE SITUATION THEORY

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Data becomes information when its creator adds meaning. One way information can arise is by virtue of systematic regularities in the world. The physics of information and communication is called situation theory. In this approach information always takes the form of a statement that some object is of some type. The regularities and conventions that enable some configuration of objects to represent or store information are referred to as "constraint". In other words, constraints are the hidden threads that connect information with its representation. Summing up, the three key ingredients that, when mixed together appropriately, give us information are: situations, types, constraints. When a person internalizes information to the degree that this person can make use of it, we call it knowledge. The possession of skill can be compared with the possession of information and knowledge. The novice skill level corresponds to the possession of data, the advanced beginner and competent levels correspond to the possession of information, and skill levels proficient and expert correspond to having knowledge. True expertise can only be achieved through practice and experience.

Key words: Data, constraint, information, knowledge, situation theory.

1. Introduction

Starting in 1995, with the appearance of the book „The Knowledge-Creating Company" by I. Nonaka and H. Takeuchi, the business buzzword "information" has tended to be replaced by "knowledge." Though closely related, these concepts are not the same.

Nor is "information" the same as "data", though these two terms are often confused. Roughly speaking, data is what newspapers, reports, and computer information systems provide us with. When people acquire data and fit it into an overall framework of previously acquired information, the data becomes information. For example, a list of stock prices on the financial page of a newspaper is data. When an investor reads this list, he/she obtains information about the market situation of various companies. What allows the investor to acquire information from the data is his/her prior knowledge of what such figures mean and how the stock market operates.

The article revisits the basics of the theory of information. It evokes the difference between data, information and knowledge, and clarifies the importance of the notions of representation, context and constraint for the concept of information. To fully understand the relations between types recognition, information and knowledge the typology of skill acquisition levels is introduced.

2. Information and Its Representation

Information is data endowed with relevance and purpose. T. Davenport and L. Prusak (1998) say that "data becomes information when its creator adds meaning":

Information = Data + Meaning

One of the most common misunderstandings is to confuse information with its representation – words on paper, diagrams, bits on disks, etc. The instruction manual written in Chinese, unless the user understands this language, gives the reader only a representation of the information. And so, the crucial role in the storage and transmission of information is played by the encoding scheme.

Information = Representation + Procedure for encoding/decoding

In this sense, computers and information systems deal exclusively in representations of information – digital representations in this case.

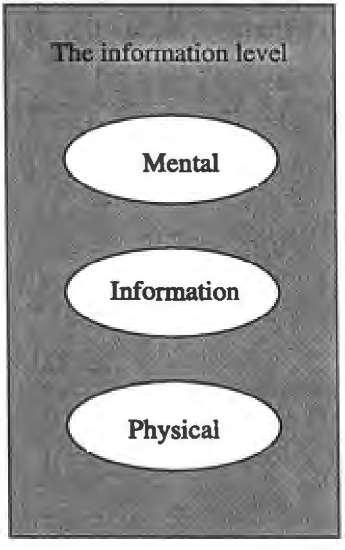

Figure 1. The information level. Source: based on (Devlin, 1999, p. 24)

Speaking of representation, it is important to stress that information is always context-dependent. The key to obtaining information is always to be found in the context, not in the representation. There is nothing special about an object that encodes information. Information is not something intrinsic to an object; it is something ascribed to it by some form of information processor.

Information can be regarded as a "substance" that can be acquired, stored, possessed either by an individual or jointly by a group, and transmitted from person to person or from group to group. As a substance, information is best thought of as existing at the level of society or even in the collective mind of a society.

Information itself is not physical; it is abstract. Whereas information is not physical, it is not purely mental either. Our thoughts are locked inside our head, but information is in some sense "out there" in the world. Whatever it is, information exists somewhere in between the physical world around us and the mental world of human thoughts. It occupies what K. Devlin (1999) calls "the information level" (Fig. 1).

3. Information and Types Recognition

At the basis of human cognition and communication lies the ability to recognize types of things. Types are fundamental to human life and so humans are type recognizers. If we were not able to recognize types, the world would always be presented to us anew, and we would be unable to acquire information from our environment or to make any reliable inferences based on prior knowledge or past experiences. It follows that one way information can arise is by virtue of systematic regularities in the world. People learn to recognize those regularities, either consciously or subconsciously, possibly as a result of repeated exposure to them. They may then utilize those regularities to obtain information from aspects of their environment. The regularities can be natural or human-made, i.e. the regularities of human language.

One problem with thinking in terms of environments is that it immediately raises the question "Environment of what?" or "Environment for what?" In order to get away from such questions J. Barwise (1989) introduced the term "situation" to refer to any possible environment or context (of and for anything whatsoever). It was this concept of a situation that J. Barwise and J. Perry (1983) took as the starting point of their new theory of information. They called it situation theory and, according to K. Devlin (1999), it is "the physics of information and communication."

In general, an object or a situation represents information by being of a particular type. The concept of types provides a systematic way to view information. The important thing to notice is that information is always information about something – information tells us something about something. This observation allowed K. Devlin (1999) to develop a theoretical approach to the concept of information using types: We shall assume that information always takes the form of a statement that *some object is of some type*.

If a is any object and T is any type, we shall use the abbreviation

$$a : T$$

to indicate that a is of type T. Using this notation, the assumption is that information is always of the form a : T for some object a and some type T. For example, the information that Mary Wallace is 23 years old is of the form $a : T$, where a is Mary Wallace and T is the type "being 23 years old." Again, the information that the profits of company X are falling is of the form $X : R$, where R is the type "profits are falling." K. Devlin refers to a single item of information of the form $a : T$ as an infon.

4. Information and the Notion of Constraint

The regularities and conventions that enable some configuration of objects to represent or store information are referred to as "constraint" (Aczel et al. 1993). This is a purely technical expression and perhaps not the best choice of word, since we often use the word "constraint" to refer to some kind of restriction. In this context "constraint" does not mean restriction, whatsoever. In terms of constraints, the information equation can be written

Information = Representation + Constraint

Constraints are the hidden threads that connect information with its representation (Fig. 2).

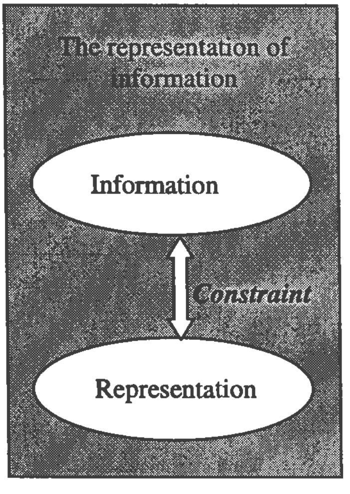

Figure 2. The representation of information and constraint. Source: based on (Devlin, 1999, p. 60)

A knowledge or an awareness of the relevant constraint, or an adaptation to it, is what enables a person to acquire the information represented by way of the constraint. For example, familiarity with the constraint that snow occurs in winter enables a person to infer that there is winter from the appearance of snow.

Summing up, the three key ingredients that, when mixed together appropriately, give us information are:

- situations,
- types,
- constraints.

This means that to obtain or extract information from some object, the person and/or the object need to be in a suitable environment (a situation), and the person has to know the constraint(s) that govern the way the object encodes the information. Similar conditions govern the extraction of information by any other "information processor", including a computer.

It follows that information can only be properly understood at the system level. To analyze the way information flows in a system, we have to:

- identify the critical contextual situations;
- identify what it is that the information is about and what that information tells us about that entity;
- identify the constraints that support the encoding and the transmission of information.

5. Turning Information into Knowledge

The value of information lies in its potential to be turned into knowledge. In the end, it is not information that we use, but the knowledge that we get as a result of obtaining that information. When a person internalizes information to the degree that this person can make use of it, we call it knowledge. Knowledge is information put into practice – or at least possessed in a form that makes it immediately available to be put into practice. Knowledge requires a *knower* and so it is largely a matter of human practice. Knowledge, then, exists in an individual person's mind, constituting human complexity and unpredictability.

Knowledge = Internalized Information + Ability to utilize it

Knowledge, unlike information, is about beliefs and commitment. According to Davenport and Prusak (1998), knowledge is a fluid of framed experiences, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents and repositories but also in organizational routines, processes, practices and norms.

Since information depends crucially on contexts and constraints, turning information into knowledge involves recognition of – and familiarity with – the relevant contexts and mastery of the appropriate constraints. Though information only arises as a result of human-generated constraints, it is somehow outside of those humans, and independent of them. As such, it is both reasonable and useful to view information as some kind of "substance" that exists in the public domain. For example, the information that George W. Bush is the current president of the USA is available to all and is surely independent of any particular person.

Knowledge, on the other hand, is fundamentally and intrinsically inside people – knowledge exists in a human mind, the mind of the *knower* of that knowledge. According to Davenport and Prusak (1998), the power of knowledge to organize, select, learn, and judge comes from values and beliefs as much as, and probably more than, from information and logic. And because knowledge is essentially inside people's minds, management of knowledge must be about the management of people. So called stores (silos) of knowledge are really stores of information that has been chosen and structured by an expert so that a person with suitable training can readily internalize it and turn it into knowledge.

6. Knowledge and Skill Acquisition

To understand the relations between types recognition, information and knowledge, we can analyze a typology skill acquisition levels proposed by the Dreyfuses (1986).

The first level of skill acquisition is what is called the novice stage. A *novice* approaches the activity by following rules, which are followed in an unquestioning, context-free fashion.

The feature distinguishing the *advanced beginner* from the novice is that, while both act in a rule-following fashion, the advanced beginner modifies some of the rules according to context. The advanced beginner has started to recognize certain types and modify the rules according to those types.

The *competent* performer still follows rules but does so in a fairly fluid fashion – at least when things proceed normally. Instead of stepping from one rule to another, making a conscious decision of the next step at each stage – behavior characteristic of the first two stages – the competent performer has a much more holistic understanding of all the rules. He has an overall sense of the activity and chooses freely among the rules for the appropriate one.

At the *proficiency* level the performer, for much of the time, does not select and follow rules. Rather he has had sufficient experience to be able to recognize situations as being very similar to ones already encountered many times before, and to react accordingly, by what has become a trained reflex.

The *expert* performer does not follow rules and indeed is generally not consciously aware of any rules governing the activity. Rather, he performs smoothly, effortlessly and subconsciously. True expertise is not rule-based. Expert behavior is rather type-driven activity, so expertise consists primarily of the ability to recognize types. When things proceed normally, the expert performer does not make decisions, follow rules, or solve problems, rather he simply does what normally works.

The possession of skill can be compared with the possession of information and knowledge. The novice skill level corresponds to the possession of *data*, the advanced beginner and competent levels correspond to the possession of *information*, and skill levels proficient and expert correspond to having *knowledge*. True expertise can only be achieved through practice and experience.

7. Knowledge and Computers

The typology described above explains why computers or information systems cannot beat people in the knowledge game. In fact, none of the systems developed in the heyday of expert systems research is currently in use. Computers cannot replace humans when it comes to the application of knowledge. As a branch of artificial intelligence, expert systems research tried to use formal logic to encode expertise into computer systems. However, genuine expertise arises when the rules are dispensed with, and such behavior cannot be encoded into a traditional, rule-based computer program. The reason expert systems technology has not produced genuine expertise is that there is always the possibility of the unforeseen circumstance. By and large, humans have evolved to respond quite well to novel circumstances but machines can't do that.

It appears that even the famous Deep Blue, IBM's purpose-built chess computer, which beat world chess champion Garry Kasparov in 1997, did not operate beyond the "competence" level. It could not develop expertise; it simply examined billions of sequences of future moves to see which one was the best. Human chess players do not work like this at all. People operate at the level of knowledge, as opposed to the more cumbersome data or information. Therefore, they can change their behavior more rapidly than a machine can be reconfigured or a computer reprogrammed.

As an example, at one of their factories in Japan, the electronic giant NEC has been steadily removing the robots from its assembly lines and replacing them with human workers. It appeared that the intelligence and flexibility of humans makes them far better equipped to cope with change than an automatic assembly line. To take a specific instance, NEC introduces a new model of cell phone every six months, so the cost of changing over to the production of a new model is a significant factor. And humans can reach a target efficiency after making 8,000 units, whereas the robot line met the target level after making 64,000 units. What is more, when both had reached peak efficiency, the people were 45 percent more productive than robots. Instead of having to spend almost $10 million to change the production line for a new model, which was the case with the machines, a model change cost less than $2 million when the manufacture was carried out by people (Devlin, 1999).

In terms of the knowledge versus information distinction, the explanation is that computers process information (strictly speaking, representations of information or data), whereas genuine, human expertise involves knowledge. And not only can knowledge lead to expert behavior, it can also enable its processor to adapt rapidly to changing circumstances.

As an additional confirmation of this occurrence, managers acquire roughly two-thirds of their knowledge through direct interaction with another person and only one-third from documents or computers. However, one should remember about a common human tendency to evaluate information in terms of the status of the person who delivers it. Instead, information should be measured in terms of its content.

8. Conclusions

The necessity for revisiting the traditional theory of information and searching for new paradigms in this milieu arises from at least a few identifiable and concrete reasons.

According to K. Devlin (1999) there is no generally accepted scientific description of what information is and we do not yet have an established science of information. As a result, we do not have the ability to properly design or manage the information flow that our technologies make possible.

Next, the arrival of the information era brings with it an information paradox. At the very time when we have so much more information, we also have to spend more, not less, time delving into exactly what this information tells us. This is because a feature of the modern business information world is the emergence of a wide range of less than 'perfect" information drawn from countless comparatively unknown information sources. In the past, decision-makers could rely on a small number of methodologically sound sources of data. Today, increasingly, we are faced with more information, much of which will have a question mark over its robustness.

Another issue worth mentioning is that despite all that we hear about living in the Information Age, what we are really living in is an age of information technology (IT), or more precisely a collection of information technologies. We might think that the information era is already at its zenith. But the real information explosion is still a little way off. The revolutions are the result of changes in infrastructures, rather than just the arrival of a new invention. D. Smith and J.

Fletcher (2001) remark that it was not the invention of the car that revolutionized transport, but the creation of the road network. Similarly, it was not the ability to build washing machines and other electrical labor-saving devices that changed household life, but the setting up of the national electricity grid.

And so it is with the information era. It is not the invention of the PC (personal computer) that lies at the heart of the new information era, but the creation of the Internet distribution channel that allows information to flow from business to business, home to home and so on. And because this infrastructure is not yet quite in place – not all businesses are "wired" with each other and not all homes are interconnected – the full information explosion has still not hit us.

The concepts of the situation theory or the representation of information with constraint seem to constitute a good starting point for further analysis within this demanding, nevertheless fascinating, field of expertise.

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W NAUCE, TECHNICE I ZARZĄDZANIU

Monografia zawiera wybór artykułów dotyczących informatyzacji procesów zarządzania, prezentując bieżący stan rozwoju informatyki stosowanej w Polsce i na świecie. Zamieszczone artykuły opisują metody, algorytmy i techniki obliczeniowe stosowane do rozwiązywania złożonych problemów zarządzania, a także omawiają konkretne zastosowania informatyki w różnych sektorach gospodarki. Kilka prac przedstawia wyniki projektów badawczych Ministerstwa Nauki i Informatyzacji, dotyczących rozwoju metod informatycznych i ich zastosowań.

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