FLOW DIAGRAMS OF THE TECHNOLOGY HIERARCHY

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Abstract: This paper re-examines the action-operation-practice-technology-experience (AOPTE) hierarchy in relation to Information Hierarchy of Ackoff and Hierarchy of Needs of Maslow, focusing on the fact that structural hierarchy (architecture), used to introduce and define major structural levels, can be left aside when the hierarchy is considered from a functional standpoint. A technological method was defined and its application in the creation of technological functional flow diagrams was illustrated. A technological flow diagram was created, integrating four flow diagrams that reflect the creation of technologies and capitalization of knowledge in human capital.

Keywords: INFORMATION HIERARCHY, OPERATIONS HIERARCHY, KNOWLEDGE HIERARCHY, FLOW DIAGRAM, WAY OF CHANGING, TECHNOLOGY HIERARCHY, TECHNOLOGY, FORMS OF KNOWLEDGE AND ABILITY.

1. Introduction

The technology hierarchy introduced [1], composed of five structural levels (elements) - action, operation, practice, technology, experience, and which could also be called „hierarchy, or operations pyramid”, or „hierarchy, or technology pyramid”, reflects the structural (more strongly) and functional (less strongly) relation between the different stages or levels of operation purification from the point of view of need, usefulness, usability and safety, Fig. 1.

Fig. 1. Technology hierarchy pyramid model (Peter Dineff, 2010) and conditions for transition to a higher level (with greater value and importance):

T1 - giving a sense or implied meaning (verbal description: What? When? Where? Who? How much?), goal setting, determining the result and the indicators, pointing to the achievements reached; T2 - knowing the application (How does it happen? How is it done? How does it operate?) and how to obtain a positive result; T3 - knowing the reasons for obtaining (Why does it happen?) a positive result and prognosticating the result with meeting the requirements for need, usefulness, usability and safety; T4 - evaluating the technology (Why is it such?), deciding to execute the operation (When? Where?) and providing effectiveness with meeting the requirements for need, usefulness, usability and safety – competence and expertise.

The pyramid model hierarchy consists in the fact that the operation is defined through the actions, the practice through the operation, the technology through the practice, and the experience or the skill through the technologies. And more precisely, by means of what the actions are not, the operation is not, the practice is not, the technology is not, and the experience is not. The pyramid model points to the fact that the actions are still not operation, the operation is still not practice, the practice is still not technology, i.e. every step of the pyramid adds value, gives importance and "purifies" the operation from the point of view of need, usefulness, usability and safety.

Ye shall know them by their fruits. Do men gather grapes of thorns, or figs of thistles? Even so every good tree bringeth forth good fruit; but a corrupt tree bringeth forth evil fruit. A good tree cannot bring forth evil fruit, neither can a corrupt tree bring forth good fruit. Every tree that bringeth not forth good fruit is hewn down, and cast into the fire. Wherefore by their fruits ye shall know them.

The Gospel According to Saint Matthew: Chapter 7, 16:20

Fig. 2. Information hierarchy pyramid model. The conditions for transition to a higher level (T1, T2, T3, u T4) are the same as those on Fig. 1.

The pyramid model is based on actions (or phenomena), which have no practical value or significance till the moment of consideration, have no connection at all to the existence of man and his needs. They are not subjected to specific aim and are still beyond organisation. At first glance they should not belong to the entire structure of the pyramid. The same applies to the top of the pyramid - the experience. The experience is something quite different. The need of acquiring experience, and the motivation for this, grows constantly and in parallel with its satisfaction, and as for the practice and technology the need of acquiring and motivation decreases with the satisfaction of these needs.

The pyramid model reveals more strongly the experience architecture as a whole and the hierarchical manner in which the basic elements of the model are defined and entered. Here again, as with the „information or knowledge hierarchy”, [2], no con-
sensus have been sought after as regards the hierarchical manner of input of the elements or the processes, which transform the model's elements of lower level into elements of higher level, Fig. 2.

The hierarchy model we have created, as well as the preceding "informational pyramid", do not exhibit strictly defined structural and functional connections. Here on the same grounds, it could be argued on the content and use of the basic notions - action, operation, practice, technology and experience.

Just like Rowly (Jennifer Rowly, 2006), [2], who lays particular stress on the functional relationships between the five levels of the "information hierarchy", in our paper it is emphasized that operation is a combination of structured and organized actions, guided in a way to get significance or value from the point of view of a specific aim or result, which makes them appropriate, meaningful, valuable and useful. Thus it is clearly indicated that the difference between action and operation is rather functional than structural. And this also applies to the other fundamental level interrelations in the technological model created.

2. Why functional flow diagrams

If we examine other well-known hierarchical models like the human needs model of Maslow (Abraham Maslow, 1954), Fig. 3, and the informational model of Ackoff (Russell Ackoff, 1989), Fig. 2, the first thing brought to the attention is the same structural approach used in levels defining and architecture (or hierarchy) setting up of the technological model, which however becomes blurred and faded when using the models.

However, when using each of the hierarchical pyramid models created, functional relations come to the fore, revealing the way the already set up architecture works or fulfills its official purpose: i) Maslow's model shows how the human needs are satisfied and how the motivation for this is brought about, ii) Ackoff's model - how knowledge is capitalized by man through his training and education, iii) Dineff's model - how a new technology is being created, reflecting the accumulated experience, skills and knowledge.

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3. Operations – needs and motivation

The technology, as a system of knowledge, is a set of paths leading to an end result, which is not in conflict with the social values and the adopted lifestyle. However the technology is connected with the choice of a given lifestyle and society shared values. The technology is based on the choice of separate, independent, real and important (substantive) values, related to the existence and realities of man and society as a whole.

The result (product) associates the technology to the choice – it is precisely with the choice of technology that man chooses his new, different way of life, his new reality. The result transfers its essential characteristics to the technology. The technology can be described through the applicability (the need for the result achieved), usefulness, usability and security. The value of the result (and of technology) appears in its use - it is designed to satisfy certain human needs and expectations.

The product acquires value only when placed in relation to man and his life, and its ability to satisfy human needs is thus assessed. Then it could be perceived as useful or harmful. "Wherefore by their fruits ye shall know them"! It cannot be said whether a technology is useful or harmful until it has been materialized through the use of tools, processes, materials and human capital, and a result has been obtained (article, tool, software). Placing the product in relation to human needs reveals its value and displays the knowledge ("stéchē") in technology.

A. Maslow builds a hierarchical model (or pyramid) of human needs (hierarchy of needs) – material (physical) and immaterial (psychological), which plays a key role in the development of human resources and the theory of motivation. Human needs, and expectations, can exist and can be aware of their existence, they can not exist, or simply not be realized, which determines the different attitude towards human existence (and society), Fig. 3, [5].

The power of motivation is formulated by: i) the value of the result, which is expected to be achieved; ii) the prospects for successful realization of the goal, evaluating the risk in relation to the existing reality.

The value of the result, and hence that of the technology, can be determined only as regards the existence of man and human society, i.e. substantively or in relation to the social or human needs.

This is also a structural and functional model that shows its hierarchy in the construction of different levels - the needs from the lower levels are stronger than those from the upper levels and any need from a lower level should be relatively well satisfied, before a need from a higher level appears. Thus a person, whose physiological needs and security needs are satisfied, has got motivation to satisfy his social needs, while a hungry homeless person remains entirely in the grip of the thought to find shelter and provide food.

It appears that when one considers himself, or what he personally needs, he looks for confidence, recognition, respect and social status, i.e. he starts from a higher level. However, if he considers the others, things become totally different – he believes that the others are motivated primarily by the needs, relating mainly to the existence (food, water, health, sleep, sex) and security, i.e. to the lower levels of the hierarchy.

At the same time the need of self perfection is fundamentally different from all other four needs in the hierarchy. All four of them represent the needs arising from understanding the short-
age, or when any of these four needs is satisfied, the related motivation decreases or entirely disappears, and human behaviour changes significantly. The self perfection, however, is totally different – it is an expression of the need of growth, and in the process of its satisfaction the motivation grows instead to decrease – another understanding appears the understanding of existence, [5].

Maslow's theory became the basic theory of human motivation and it is undergoing changes emphasizing increasingly the way human needs are satisfied and the motivation for this. Even the power of the hierarchical relationship is denied, but the functional relations between the different elements of the diagram remain. It is recognized that human needs are finite, limited and are subject to categorization, are constant for all people around the world and all historical periods. Changes affect only the means, the routes and the methods through which these needs are met.

What is important for us is that Maslow's model expresses the means of satisfying human needs and expectations from functional standpoint. In this sense the needs are seen as a system - the levels are interconnected, interact and change. The interdependence between the elements, related to the satisfaction of needs, remains strong, while the hierarchical dependence between them becomes so week, that it can be easily ignored.

The main conclusion that can be carried over to the group of technological models consists in the fact that once established hierarchically the architecture of the needs becomes important for the revealing of the methods and motives to meet human needs, or more clearly - in the use of this model the functional links in it acquire importance. This remains valid for all models in this class, including the information and technology models.

3. Technological and scientific method

Knowledge is a good, which can be capitalized and become a means or agent for creation and production of goods (goods and services) in two ways: i) through creation of technologies; ii) by transformation of knowledge in human capital through training and education.

By means of the skills and knowledge acquired in the course of the educational process, people increase their ability and capacity to produce goods. Human capital is a factor of production with unlimited opportunities for growth.

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The technological method reflects the specificity of the technological operation, namely the need of structure, organization in time and space, and management of operations and phenomena (processes), to ensure an effective outcome. Each technology ensures the achieving of end result at minimum cost, which should be sufficient to provide effective management of the safe and hygienic working conditions, protection and recovery of the environment, business continuity, information security and risk assessment. The control over the use of the artefacts is placed in the centre of technology, because technology should be seen as a product of shared values and a lifestyle adopted by society.

Science and technology reflect man's attitude towards the surrounding reality. Man tries to find his place in this reality, sepa-
rating himself and his needs from it. Science, as a systematic knowledge, is a set of methods (ways, means, approaches, modes, manners, practices, techniques), through which the research as a motivated investigation (or study) of natural phenomena, increases human knowledge about the surrounding world and the human being.

The object of study of both science and technology, are the natural (physical, chemical, biological) phenomena. Science, however, covers operations, which expand the knowledge about the natural phenomena, while technology includes operations, expanding the notions of these same phenomena, but in terms of their use for creation and production of artefacts – do they lend themselves to structuring, organization and management, and can they be viewed as goal-oriented processes. Science is cognitive oriented, while technology is pragmatically oriented - broadly speaking, research derives information from surrounding reality, while technology uses this same information to satisfy human needs.

Technologies significantly affect the development of human society, as they not only enable man to adapt successfully to his environment, but also help him create an environment managed by him. It is through technology that man begins to use natural resources more effectively, [3].

4. What does the information diagram show

Comparing the two methods – scientific and technological, indicates that the information diagrams do not reflect the application of the scientific method, which means only one thing – the knowledge that is formulated is not the knowledge «epistémê», but the knowledge «téchne», reflecting the essence of the technology and that of the resulting product. Both information and technological models are subject to the technological method. Then what do the well known information models reflect?

Johann Backmann (1772) was the first to introduce the science for the essence, contained in «téchne». We should not forget that the artefact is produced by «téchne», which is at the same time the carrier of its essence (what is). So, as a result of human activity an artefact is produced, which gets the essence from the technology and becomes its carrier. The use of the artefact to meet the human needs displays this essence and makes it visible. Placing the artefact in relation to the human needs reveals its essence. Satisfying the needs - that is the act which separates the existence (he is) from its essence (what is). Knowledge in «téchne» is revealed only after the materialization of the technology and the production of the artefact (the product), in order to be used.

Knowledge in «téchne», or the essence of technology, can be revealed and studied separately, which explains the possibility for parallel construction of two sets of hierarchy diagrams - information and technological. The information corresponds to the "technology by description", or the activity (operation), – verbally and logically, the knowledge corresponds to the «technology by prescription or procedure» (practice); the comprehension - to the technology; the wisdom (insight) - to experience (mastery). The disclosure of «téchne» when using the artefact allows only the separation of the technology from the knowledge, which it brings.

Thus, the knowledge (or «téchne») is a good, which can be used for final consumption or capitalized in order to become a tool and a factor of production. The information model shows the way «téchne» is capitalized and turned into a factor of production. And vice-versa, the knowledge finds its application through technologies and production. The technology, in turn, is regarded as an intangible product of knowledge, materialized in terms of production. It produces a result (a product), which reveals its essence when placed in relation to human needs. Engineering and business make it possible to realize the production of the product on a scale sufficient for use by society.

Knowledge, once revealed and separated from technology, can be used without being checked every time – the experience affirms the knowledge, it can be stored, spread, shared and used. Moreover, it can be capitalized through education. Human capital, consisting in man's ability to produce, shows unlimited possibilities for growth.

5. General information and technologic flow diagram

The technologic flow diagram was introduced by Dineff (2010), [1, 3], by analogy with the existing information flow diagram.

The operation is defined in terms of the actions, just like the information is defined in terms of the data. If the information hierarchy diagram, Fig. 2, irrespective of its presentation, takes a central part in the information theory and the information systems theory, in the information management and the knowledge management, then the technology hierarchy diagram should take its place in the technology, the technological systems and the technology management. The conception of information, knowledge and understanding is compared in a specific way to a new conception of the relation between the operation, practice and technology in a similar hierarchy model, Fig. 1.

Externally, actions do not seem to belong to the model created. Here, the actions are opposed to operation in the same way as the data are opposed to information in the information hierarchy model.

Actions have no meaning, practical significance (relevance) and user value for man - they have no explanation attributed (interpretation) or implied meaning (context). Actions are not organized according their purpose, or are not oriented to a particular aim and/or result - they are not useful. Actions are not subject to control as they have no explicit goal or applicable result. Actions, however, are objective and observable, they are discrete and can be verbally and quantitatively described, can be studied and analysed.

The activity (operation) consists of a set of actions which are assigned a meaning through interpretation or subtext. Operations already bring benefit as the constituent actions are organized by purpose (expediently) and are oriented towards the pursuit of a goal or outcome. The operation acquires practical significance or value depending on the applicability of the result. The operation is a set of selected actions only, which can add more value to the result. The operation is visible and real. It can be easily described, copied, and transferred. The operation can be regarded as "a technology by description," a product of our verbal and communication.

The technological method allows by multiple realization of the operation (or natural phenomenon) to reveal the opportunities for purposeful organization and effective management of the operations and processes. The first of the usable technological products appears - the activity (operation), or technology by description (what, when, where, how many, who).

This process of operation purification through observation and experience, however, is in itself a process of extracting information about the activity (or process) through processing data collected by observations and measurements.

The two flow models can be combined, as the data transformation can hardly be separated from the action transformation. The information saturation of the operations increases their efficiency, as the efficiency of the operations adds value to the information received. If the emphasis is put on the purposeful organization and management of the operations, then one
Fig. 5. Flow diagram (I know and I can), showing the methods (ways, modes) of interrelation between the activity and information along the way of change, determined by motivation and human needs: 1 - informational or knowledge model (no interrelation); 2 – operational or technological model (no interrelation); 3 – wisdom model (power); 4 – experience model (strength). The human needs are shown (according to Abraham Maslow) as well as the forms of knowledge and ability, corresponding to the satisfaction of these needs.
naturally gets a technology model that ends with the creation of a technology, which acquires maximum value and carries maximum useful result (production of an article or service). If, however, the emphasis is put on the creation of human capital through training and education, then we get the information flow model.

Man increases his abilities and capacities to create and produce - on the one hand, to obtain and process information, to transform it into knowledge and understanding, and on the other, to improve his skills, to structure his actions by setting a goal and give them a purpose, to organize and manage the operations.

Man is the one who combines the two flow diagrams – he is the one who can set a goal and transform the data from observations and measurements into information and from one unorganized and uncontrolled set of actions into a purposeful activity.

The two flow models can be combined in one generalized model, showing how knowledge appears and turns into a means of creation and production - first, by the direct conversion of operations into technologies, and secondly, by transforming the information into knowledge and understanding in man, who acquires skills and abilities to create and produce. If information makes people committed to knowledge and understanding, operations make people committed to practice and technologies.

As Rowley defines information like „knowledge by description“, [2], and says that „the information is contained in the description, and it differs from the data in that it is useful“ for making a decision or for an activity, so does Dineff determine the operation as a “technology by description”, which is useful for obtaining information or for creation and manufacturing of a product (article or service). If the information can be obtained from the data by answering questions, and thus described (for example “who”, “what”, “where”, “how”, “when”), the same can be said with still greater certainty for the technological operation (or activity). The operation is explicitly defined by the invariability in the following features: i) the working place (“where”); ii) time and duration (“when”, “how long”); iii) a qualified person (“who”, “what”); iv) the contents (“what”) of the operation; v) the technological means – tool, process (“with what”). Thus the purposefully created structure of actions, forming the operation, becomes useful and acquires value.

It should however be remembered that the information, contained in the operation, is separated from it through the result, which has a real consumer value. This can be the newly obtained information or the product manufactured. The generated information should be useful for the decision making or for operations implementation. The product manufactured must have a determined official purpose and a clear consumer value.

The proposed flow diagram is subject to several conditions, Fig. 5: i) technology is perceived as an immaterial product of knowledge a person acquires in the course of his training; ii) understanding is seen as an immaterial product of practice in which man takes active part; iii) engineering has for result the substantial realization of an already existing technology; iv) three pairs of concepts form the main part of the functional flow model structure - information-activity (operation), knowledge-practice, understanding-technology, which are mutually determined; for example, information and activity are inseparable and unrecognizable until getting result and evaluating it; only then is the information about the activity separated from the activity itself; v) the data, as well as the actions, belong to this model only because through them is revealed the way they acquire sense and turn into information and operations; vi) wisdom and experience can be considered independently outside the model because they relate to the choice or decision, which makes a technology or an understanding preferable to many others; vii) placing the couple “wisdom-experience” in the future reveals one more prerequisite for this realization - the presence of various understandings and technologies in order to make the right choice and take the right decision; viii) the highest level in information enrichment is rejected - enlightenment, proposed by Zeleny (M. Zeleny, 1987) concerning the question of truth, the correct and incorrect (right) things, the right things and their social impact - acceptance, compliance or rejection. Wisdom, however, includes also a choice or decision making based on knowledge and experience - a cognitive aspect of choice corresponding to the values and lifestyle adopted by society - ethical and social aspect of the choice.

The setting up of the flow technology diagram is subject to various changes (transformations) that accompany the transition from one level to another and apply to both the information and the operations:

- significance, goal orientation;
- applicability, importance and value;
- succumbing to transfer and expansion in application;
- input (and storage) and human participation - stored in man and/or computer;
- susceptible to formal logic and algorithmization;
- programmability;
- order and structure.

Some of these changes expand with the transition from operation to expertise and from data to wisdom – the applicability, the significance and the value, the transfer and the expansion in terms of application, compatibility, order, value, security etc. Other, on the contrary, on the way to understanding and technology decrease and become inapplicable – the susceptibility to logarithmization, the participation of man, the creation and the use of software products, the operation automation.

The storage, sharing and spreading of information can be done by man, by computer, through libraries, computer, library and communication networks. The information is visible, real, and independent of the actions and decisions. The information can be presented in different formats after processing – with the help of alphanumeric code, verbal, graphic, could be stored and spread by paper printouts or electronic records. Something more, information structuring and processing can be formalized, automated and saturated with technical means, as this could be done for the operation.

The resulting product, regardless of the existing environment can easily be transferred and copied. It can be accessed, transferred and exchanged. It can be processed in appropriate way, can be converted into a series of electrical or optical signals and carried at distance through communication channel. The information management is mainly concerned with creating, delivering, capturing, coordinating, combining, processing, and spreading information. The information is updated, expanded and systemati...
It is always started with the so-called "tacit" or inner knowledge (Jan Duffy, 2000) and practice which are personal, undocumented, informal, not explicit but context-dependent, internally generated, concrete, based on experience, dynamically changing, residing in human mind, behaviour and perception. The practice is implied and "silent", deeply rooted in one's own experience, opinion and intuition - like knowledge it is difficult to express and communicate (Ikijiro Nonaka, Hirotaka Takeuchi, 1995).

On the contrary, "explicit" knowledge and practices are socially significant, documented, formal, structured, with fixed content, context independent, external and residing in human consciousness. It is no easy task to motivate a person to participate and share his knowledge and practice. Only about ten percent of knowledge and practices in an organization are of public importance, so sharing and transferring of knowledge and good practices should be encouraged. Information, after being individualized in the course of its use and verification, is a public good that makes people committed to the knowledge. This is also true for the practice.

The transition from activity (technological operations) to practice is a transition from something that is visible, real and independent of man's actions and decisions to something quite different - practice is invisible, immaterial, closely related to the actions and decisions, firmly subjected to the result, which determines completely its value. Practice is a "technology by prescription (procedure)" which can also be tacit or explicit practice, depending on whether it is personally or socially significant practice, whether it is undocumented or documented and official. Practice can also be good or bad, depending on whether it meets certain legal regulations, human values and chosen way of life.

Knowledge, however, can be separated from practice only after getting the result or achieving the goal set. Then the practice and the knowledge for it can be differentiated. Practice can be evaluated after the outcome transfers its characteristics on it - only then the practice becomes significant, valuable, worthwhile, useful and relevant.

Education allows transfer and sharing of knowledge and practices. Practice is transferred or acquired only through training, while operation can be acquired just by copying the description. Not only most of the knowledge, but also most of the practice remain "silent" unshared, personal achievement and possession, difficult to express and communicate.

Some people fear that after giving their "know-how" they will be no longer valued or needed. Others are far too much individualists and egotist, happy to use other's experience, but never share their own.

The main source of wealth is not only knowledge and practices, but also communication between people. Without communication between people in a company knowledge cannot be shared and expanded. Trust and willingness to cooperate are crucial for the normal existence and development of a man or a company.

Practice is "technology by prescription", requiring rigorous control on the implementation of the regulation, prescription or procedure in order to get the best of the expected result. Knowledge is acquired after getting the outcome of the practice, but the other is also true - putting knowledge into practice turns it into means of production.

Understanding as well as technology remains invisible, intangible products, closely related to man's (company's) actions and decisions, spiritual products that can be transferred and shared only by training. There is however a new, considerable leap in the growth of importance, value and significance of the operation (and information) - technology ensures an effective result achievement even in the event of changes in the environment, including new restrictions, realization of threats, incurring damages.

Drucker (Peter Drucker, 1993) makes a clear distinction between post-capitalist and capitalist society, putting emphasis on the primary role of knowledge - the role of knowledge becomes paramount - not the practical sphere of activities, but the knowledge sets problems before science, and the scientific knowledge development, in turn, determines the tendencies and tasks for practice development. Success becomes a function primarily of the use of new knowledge and skills and new forms of organization and management.

In the centre are the tacit, implicit knowledge and practices which turn into leaders the educated men and organizations. That is why knowledge nowadays is associated with wealth, which does not consist in possession of a number of tangible products (products, services, money, etc.), but in personal knowledge and skills which once created are constantly multiplying and changing. New factors acquire a key role: human capital, new technologies and innovations, creation of new products and processes, profound changes in production organization and management.

The possibility to separate information from operation, knowledge from practice, and understanding from technology allows the realization of new hybrid models in which external tacit knowledge and practices can be shared, spread and used when wisdom and experience are reached, Fig. 5.

**Conclusion**

A flow diagram has been created, which combines the information and technologic diagrams, realizing two more different ways (modes) to reach wisdom and experience based on the following: the hierarchy model reflects the structure (architecture) of the different levels of information and operations purification from the point of view of their utility; the flow model reflects very well the functional dependence of the different levels, showing the stages of information and operations development and change; the models proposed are built on the basis of the suggested technology method, which allows information to be separated from the operations, knowledge from the practices, comprehension from the technologies and wisdom from experience – the materialization of the technology, the obtaining of the product or the result and placing it in relation to man and his needs, allow this separation - each artefact is produced by "tēchnē", which is the carrier of its essence; each knowledge, skill, technique or science, connected to creation or operation, performed by the human being to produce artefacts, is related to "tēchnē" - this is the knowledge embedded in the model; the linear functional model reflects the information and operations change as a process, in which their value, usefulness, importance, etc. increase from the entrance to the exit.

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