Modeling of Competence as a Tool of Goal Setting for Education in Modern Society

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Abstract: ***The purpose of this article is to examine problems related to the role of the educational system in the development of society, with the objectives of modern education in preparation for professional performance. Authors have analyzed the competence-based approach in education. They propose original structural and mathematical model of intellectual competence, methods for its evaluation and presenting its profile. The authors conclude that the purpose of education in modern society is to shape humanistic motivated competent individual.***

Index Terms: role of educational system; competence; remit; competence-based education; intellectual competence structure.

I. INTRODUCTION

Specification of the theoretical, primarily socio-psychological foundations of approaches to education is required for determining the role of education in a modern society and validation of the purpose of the educational system as a subsystem of a society [1][4]. Nowadays we observe spread of the performance and competence approaches at all levels of education beginning with secondary school and ending with higher education at the universities [5][8]. [9] in "The methodological essence of competence approach" suggests "to identify the methodological significance of the competence-based approach to the theory and practice of educational activities. ... What theory has laid down foundations for competence approach, what are its principles and what scientific context originates its categories?"

Answering those questions the author argues that foundations of the philosophy of the competence-based approach represent a synthesis of pragmatism and existentialism, because these ideas appeared to replace the philosophy of the Enlightenment, which in its turn represented a foundation of knowledge-based pedagogy.

However there are substantial reasons to mount a challenge to the idea that a competence-based paradigm *replaces* the "knowledge-based" one.

How one can answer the question "Did Archimedes possessed a competence?" First, it should be clarified what area of the activity the question is about? Every competence may be evaluated only in a determined area of activities (the remit). Second, one can set a more general question: "Whether the object has had a certain property, when that property had not yet been discovered and studied?" For example, "Did radium was radioactive, before the discovery of radioactivity?" The positive answer is true. Then the answer to the question about Archimedes will be positive when physics or geometry are indicated as areas of activity (the remit). But in case the question concentrates on another random area such as hockey (or other areas) the answer will be negative. Did Enlightenment Yan Komensky's Century was over like the Stone Age? The Stone Age did not end because stones had vanished; it ended because stones had ceased to be the best material for tools. Century of Telegraph ended not because telegraphs had disappeared, but because radio had proved to be more effective.

The Age of Comenius cannot end, because the primary and school education now represents the foundation and cornerstone of education in general. Modern architecture of superstructure and the upper levels of the building of human knowledge must be built in a different manner. The Age of abstract knowledge is being replaced by the century of competence. This happens not because we witness abandonment of knowledge, but because the knowledge itself is not enough. The classical approach resting on the assumption of the necessity to assimilate all knowledge accumulated by the mankind has reached its limits.

Warrior, finding himself at the cutting edge of contemporary science, may not have his own martial art, but must have personal qualities of the warrior and main advanced research weapons. Those qualities will form the competence within such area of activities (*remit*), that is "the cognition of the Nature".

The abovementioned paper also argues that "parting with the ideas of the Enlightenment philosophy and at the same time with the" pedagogy of knowledge ", on the one hand, is too premature. However, on the other hand - the changed historical conditions require clarification of this paradigm, its modification, but not rejection, in any case" [9]. After philosophical studies and determining the role of competence-based approach in the development of society, the author concludes that "the competence-based approach is a method of modeling of a goal of education" [9].

[10], in his numerous works devoted to the simulation of the interaction of social forces and the educational system, along with G. Morgan, M. Bukchin and other scholars, offers to consider a system "people - society - Planet Gaia" as autopoiesis, to find ways to use interactions and feedbacks loops of this system to maintain its sustainable development.

At the same time [10] considers changing the paradigm of modern education as the primary mean of

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preventing modern society from self-destruction. Such paradigm change assumes transition from the accumulation of excessive knowledge and plantations of senseless actions to the formation of a variety of competences of school and then university students, based on an individual approach to learning and development in the broadest sense.

[10] explains: “The word “education” comes from the Latin root “educere” … which means “to draw out”. This implies – and most teachers, pupils, parents, and educational philosophers agree – that the primary task of an educator is to draw out the diverse talents of children, pupils, students, subordinates, other course participants, or apprentices. Yet most teachers don’t do this. And they will point to many constraints which prevent them doing so”.

Considering the traditional goal setting composed to educate “initiative, problem solving, creative… resourcefulness ... and understanding of the functioning of society” he writes: “For almost a century in the most widely cited books in teacher education. Some American school systems poured vast amounts of time and money into educational programmes seeking to foster. But, in fact, few schools do much work in these areas. Goodlad made the point forcefully by saying that, in general, the activities in which most pupils are engaged for most of the time in most schools do not merit description as academic or intellectual: They fail to nurture such qualities as judgment, analytic ability, the ability to interpret, the ability to communicate, the ability to reconcile different points of view, or critical thinking " [10].

In his conceptual model of the interaction of social forces, including a plurality of feedback loops J. Raven has identified several "NOT" as key links: "NOT-satisfaction (dis-satisfaction) with the educational system", "NOT-ability (inability) to design competency oriented educational programs", " NOT-existing (lack) of understanding of Nature, Development and Assessment of competence, and, especially its basis in values" et al. [10].

Modern reality makes it not only possible but rather indispensable to enforce the transition from “thinking about abilities” to abilities themselves, the transition from perception of education as primarily concerned with the transfer of “knowledge that” to the perception of education as primarily concerned with formation and development of competences, combining “know that” and “know how”, the transition from the consideration of “intelligence” as a kind of relatively unchanging quality of the individual to the intellectual competence, which depends on the group in which individual is involved and area of activity (i.e. depends on remit).

Covering the complex structural and substantive diversity of competences writes that in education “the objective was not that they should “learn” in the sense of acquiring stocks of standard, formal, low-level, verbal *knowledge*” and emphasizes that the education must has “the ability to build up idiosyncratic combinations of up-to-date specialist knowledge – yes – but that was different”.

Thus, a goal of education, presented as the formation and development of the competencies of students, enabling them not only to professionally perform the activities entrusted to them by society, but also to be motivated to act within their remit (and even outside them) focusing on long-term interests of society and humanity as a whole.

It should be noted that not all researchers believe that the competence-based education is panacea against threats to human society.

Critical attitude towards competency-based education is associated not only with the uncertainty of the terminology. The work of Professor Melbourne Institute of Technology [12] was named ‘Competency-based education – neither a Panacea nor a Pariah’. The author examines the origin and evolution of competency-based approach in the educational systems of the US and the UK since 1960s, and reveals both the positive aspects related to "behavioral" competences, and contradictions resulting from this approach. J. Bowden proves that current students have to deal with unpredictable work and that is why they need to learn in such a way as to "develop their capacity to discern the relevant aspects of relatively novel situations. It is suggested that this is best achieved by including contextual variation as part of the learning experience". It turns out that "In order to become capable of dealing with a varying future we must have met a varying past". The author's conclusion is quite constructive and the fact that formed today competency-based approach should be adapted "to deal with the unpredictable future by moving away from the prescriptiveness of earlier and less helpful versions and by embracing the principles of variation argued for in this paper" [12].

II. METHODOLOGY

published a manuscript 'Personality and Intellectual Competence' [13], which presents an analytical review of the psychology of personality and intellect, and their interaction with other factors of academic and professional activities. The authors attempt to develop a comprehensive model to understand the basic aspects of personal qualities, their measurement and the relationship with cognitive ability, efficiency of scientific and production work, as well as self-assessment skills (reflection) and creativity. The authors have generalized the study of the last century in this field. Such generalization establishes a systematic theoretical framework for understanding the future direction of psychological research. This book combined theoretical knowledge with application issues, and became an effective research tool. The authors have shown that the non-cognitive factors, such as interest, motivation, and personal qualities begin to play an important role in the formal education system. These factors may interact with cognitive abilities and even send them to the development of intellectual competence. Thus, the decline of the predictive power of tests of psychometric intelligence in relation to academic activities at more advanced stages of training may entail an increase in the predictive values of non-cognitive factors: "abilities are only one part of the complex causal framework that determines whether a student pursues the acquisition of knowledge and skills within a particular domain. Two other components of the equation are interests and personality traits" [13].

Speculating on structural modeling of competence [14] directly depicts the problem of presentation of competence similar to the description of complex chemical substances by means of Mendeleev's periodic table of chemical elements in the notation: «We will now push the chemical analogy further. If we were to pursue this model we would find ourselves writing summary descriptions of people and the environments in which they live and work. This might take the following form (the symbols that are used are exemplary only and should in no way be taken to suggest that we have developed even a preliminary version of a more complete table of "human elements"):

$$Achs_4Pow_3;\ Auth_4PartCit_2;\ NuP_4HostP_3;\ DP\ (T)_1.$$

Such statement might be interpreted to mean that the individual concerned showed a spontaneous tendency to display four components of competence in pursuit of achievement goals and three components of competence in pursuit of power goals ».

Having chosen a similar path simulation, as the elements that make up the "molecule" of intellectual competence (IC), we consider four basic basis competence, to which can be reduced all intellectual activity [15]. Thus we assume that all kinds of problem solving boils down to four activities: algorithmic (A), deductive (D), inductive (I), language (L). Thus,

$$IC = M \otimes (A \oplus D \oplus I \oplus L),$$

where M is motivation.
Motivation having sign-defining role determines the direction of competence depending on the motives of activity, that is, the personal values.

Constructed model does not reflect the partition of IC on basis competence, but represent the identification of their participation (share) in reaching of decision. We need to visualize the set of points in 4-dimensional (!) with coordinates (x_A, x_D, x_I, x_L). But if we assume that all shares are in the amount of the unit, i.e.

$x_A + x_D + x_I + x_L = 1$,

then a three-dimensional representation by the 3D-simplex will be possible and visualized as the right three-dimensional tetrahedron.

Every face of the tetrahedron shown in Figure 1 corresponds to one of the base competencies: A-face - algorithmic competence; D-face - deductive (logical) competence, I-face - inductive competence, L-face - language competence.

This representation demonstrates that the IC has not hierarchical structure, but the complete graph structure that ensures the interaction of all components of competence between one and other. Moreover, its own meaning acquires all edges of the tetrahedron and all its vertices. Edges illustrated the pair interactions and vertices - ternary interactions of base competences when a particular problem is solved.

III. IMPLEMENTATION

The manifestation of intellectual competence in problem solving is shown by a point (x_A, x_D, x_I, x_L) inside the tetrahedron. Here x_A, x_D, x_I, x_L are the distances to corresponding face. The distances characterize the degree of manifestation of base competences set out in the corresponding face (Fig.1).

Points inside the regular tetrahedron have important property : the sum of the distances from any point to the four faces of the tetrahedron is equal to 1. The vertices of the tetrahedron correspond to the "absolute" one of the base competences: S (Syntax) - ($x_A = 0$, $x_D = 0$, $x_I = 0$, $x_L = 1$) - syntax without semantic; A (Automatism) - ($x_A = 1$, $x_D = 0$, $x_I = 0$, $x_L = 0$) - "Chinese room» (asemantic activity); Im (Imagination) - ($x_A = 0$, $x_D = 0$, $x_I = 1$, $x_L = 0$) – imagination; R (Reaction) - ($x_A = 0$, $x_D = 1$, $x_I = 0$, $x_L = 0$) – predefined response to a stimulus (finite-state machine logic).

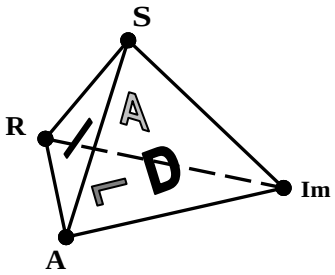

Figure 1 - Four-component model of intellectual competence (IC)

Indeed, at the points corresponding to the pointed vertices only one of the base competences manifests itself, the degree of its manifestation is 1, and the remaining competences have degree of manifestation equal to 0. For example, according to a strictly defined algorithm steps (manifestation only of algorithmic competence) transforms man into "Chinese room» (J. Sirl), a such "mind" is illustrated by vertex farthest from the A-face. The vertex I is "without language", "without deduction" and "without algorithm" thinking provided by the interaction of knowledge and concepts at the level of mental representations, i. e. Absolutized Intuition (phenomenon of outstanding mathematician Ramanujan must be taken into account).

We can consider mutual complementarity of each pair of base competences: D – L; D - A; D - I; L - A; L - I; A - I. Consider one such pair, namely the interaction of deductive (D) and language (L) competences. Language competence is not limited and is not reduced to speech or possession of a natural language, but it is a tool of communication with another individual, with another myself, finally, with the world (e.g. attempts of mankind to establish a contact with another civilization through language messages launched into the space with the hope that inductive, deductive and algorithmic competence of representatives of another civilization would be mature enough to understand the language of the message and conclude that the authors of the message received have an ability to algorithmic, deductive and inductive performance and that is why they represent a reasonable civilization). But a language without deduction can only be a rambling speech. Words can have a definite meaning. For example, a

child reading a newspaper text and do not understand the sense of no one word manifests the language competence at the level of distinguishing alphabet characters, drawing the syllables and words, transformation them into sounds (i.e. translating the written language to sounding language), but it does not manifest competence in understanding of the text.

Again there is the specter of the "Chinese room" which absolutizes algorithmic component of language activity.

A set of points for which the $x_D + x_L = 1$, and therefore, $x_A = x_I = 0$, is the edge S-R. Indeed in this interval nature of thinking is changed by the reaction to the stimulus R (e.g. "if condition 1, the effect of 2, ..., and if the condition n, the effect of n;») to asemantic syntax S (e.g. favorite "Jabberwocky" by Lewis Carroll: 'Twasbrillig, and the slithytoves / Did gyre and gimble in the wabe').

IV. RESULTS AND DISCUSSION

It is important to emphasize that the components of intellectual competence are called competences, not only abilities. Thus, it is assumed that each of the base competences has its field of application; has own motivational component; is the mobile in relation to the various spheres of activity; has its own reflection and self-improvement opportunities. For example, we can talk about recursion as about algorithmic reflection, or talk about the language creativity (analogy of metaphors), or inductive motivation (imagination, abstraction), or the deductive creativity (Pascal's mathematical induction).

Let mark the edge of the tetrahedron by letters of incident to it competence-faces united the sign "&". It is assumed that base competences that correspond to those faces "almost do not participate" in this combination.

Then a combination of base competences can be interpreted by logical formula, which shows that in the absence of manifestation of those competences, the manifestation of all intellectual competence make up by the remaining base competencies. Then we get:

$A \oplus D = \overline{I \& L}$ - the degrees of competences satisfy the conditions ($x_A + x_D = 1$, $x_I = 0$, $x_L = 0$) – this is the manifestation of algorithmic (A) and deductive (D) competences which provides algorithmization of deterministic systems (e.g., computer program «Deep Fritz», winning the World Chess Champions among people realize these components of competence, but not the competence; another example of such combination is expert systems technology in artificial intelligence);

$A \oplus I = \overline{D \& L}$ - the degrees of competences satisfy the conditions ($x_A + x_I = 1$, $x_D = 0$, $x_L = 0$) - manifestation of inductive (I) and algorithmic (A) competences ensures realization of the heuristic algorithms based on inductive solutions, not proven deductively and not formulated verbally;

$D \oplus I = \overline{A \& L}$ - the degrees of competences satisfy the conditions ($x_D + x_I = 1$, $x_A = 0$, $x_L = 0$) - manifestation of inductive (I) and deductive (D) competences provides proof of mathematical theorems, including their formulation (a rigorous proof of the inductive hypotheses);

$I \oplus L = \overline{A \& D}$ - the degrees of competences satisfy the conditions ($x_I + x_L = 1$, $x_A = 0$, $x_D = 0$) - manifestation of inductive (I) and the language (L) competencies provides formulation of analogies and hypotheses in the language of a particular discipline (description of analogies, the formation of hypotheses on the basis of analogy);

$A \oplus L = \overline{I \& D}$ - the degrees of competences satisfy the conditions ($x_A + x_L = 1$, $x_I = 0$, $x_D = 0$) - manifestation of algorithmic (A) and the language (L) competencies ensures, on the one hand, algorithmic notation, i.e. the language of writing algorithms (Backus-Naur form, musical notation , recording of chess game, recording of the algorithm of numbers division, programming languages), and on the other hand, the algorithmization of language operation (syntax analysis, automated translation, for example, recording the number by words);

$D \oplus L = \overline{I \& A}$ - the degrees of competences satisfy the conditions ($x_D + x_L = 1$, $x_I = 0$, $x_A = 0$) - manifestation of deductive (D) and the language (L) competences provides a description of the of inference in natural language or in the language of formal logic (syllogism, modus ponens).

In the vertexes of a tetrahedron three faces converge, allowing "no manifestation" of three base competences and those vertexes are interpreted as:

$A = \overline{I \& D \& L}$ - Strict algorithmic action;

$R = \overline{I \& A \& L}$ - Reactive behavior (finite-state machine logic);

$S = \overline{A \& D \& I}$ - Syntax (language with syntax rules, but without semantics);

$Im = \overline{A \& D \& L}$ - Imagination (Imagination).

At the same time, for example, a combination of inductive, deductive and linguistic competencies (without any noticeable manifestation of algorithmic) I⊕D⊕L represented by a point on the A-face, for which $x_I + x_D + x_L = 1$, $x_A = 0$. This combination provides a rigorous mathematical proof of the inductive hypotheses, correctly described in the respective language of functions (but without algorithms). Finally, Int = A⊕I⊕D is a special face appropriate "no manifestation" of language competence (L-face). That component is *intuition*.

As was mentioned above, each point inside the tetrahedron presented characterizes a certain structure of intellectual competence manifested in solving the problem. The higher the point over the face of the tetrahedron, the higher degree of manifestation of competence corresponding to this face. Since the sum of the heights, descended from an internal point of the tetrahedron on the faces is constant intellectual competence structure can be characterized by weight coefficients $<x_A, x_D, x_I, x_L>$. This property of the model will be used for testing the structure and level of intellectual competence (IC) as a whole.

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The interior points of the tetrahedron performs "mind" (mental structure) of a particular individual, described by four degrees of manifestation of base competences. Each point (x_A, x_D, x_I, x_L) is located at a distance proportional to the degree of manifestation of the competence corresponding the face. Another way to reflect the same IC structure is the "intellectual competence profile" [15], an example of which is shown in Fig.2.

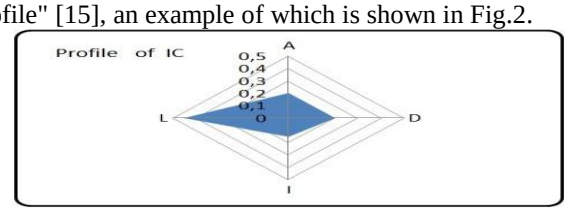

Figure 2 - Profile of intellectual competence
IC = (A, D, I, L) = (0.20, 0.20, 0.15, 0.45)

Presented profile, built through a computer program processing IC structure on the base test results, complies with the following degrees of manifestation of basic competences $x_A = 0.2$, $x_D = 0.23$, $x_I = 0.16$, $x_L = 0.41$. The profile presentation and classification of psychological constructs are widely used in psychological testing, but the profile does not reflect the interaction, and only characterizes the concrete manifestation of base competences in the structure of the IC.

So, the nature of intellectual competence, is not reducible to any mechanisms of brain activity, neither to a comprehensive description of the phenomena in any language, nor to a strict logical relationship concepts, nor to the imagination or intuition, nor to the formulation of complex abstract laws. It is a living unity of listed and many other components. It is necessary to recognize that the nature of IC is comparable only to the nature of the activities carried out, in which IC is manifested, and the wider range of knowledge, the more developed human intellect of the knower, the closer it is to the harmonious combination of diverse manifestations and abilities.

The purpose of higher education cannot be reduced to "the preparation of the competitive expert" [16][20], as well as the purpose of a distant trip could not be getting of convenient place on the train. The so-called "turn the face of the University to the employer" means that an employer ... turns his back to the university. Such goal setting limited the education system. Targeting such activities [21] says that limited educational activities: “Generates incompetence; Produces qualities that are personally and sociologically useful in the short term, but dysfunctional in the longer term”.

It should be noted that for the appropriate determination of goals of educational system and setting tasks to achieve them the correct terminology is wanted. This will allow researchers and practitioners of training to understand each other and formulate general conclusions. Questions of terminology of competence-based approach are well researched in different countries [15][22][24]. The authors substantiate the value of the concepts 'competence' as ‘motivated abilities’ (agree with J.Raven) and connect it to the area of activity (remit) and criteria for achieving the goals in this area.

V. CONCLUSION

The purpose of higher education is to form humanistic motivated personalities competent in their chosen remit. In this case one of the important property of competence is its mobility, which allows to adapt the professional activity to new remits. Motivation is determined by personal values and distinguishes the humanistic activities from highly targeted activities directed to the detriment of the society in the long term. Competence structure is described by proposed model, which includes base competences: algorithmic, deductive, inductive and language competences. System interaction of personal qualities, procedural and declarative knowledge, reflection and creativity *generate an emergent property of the system "education-personality-society"* which can be termed as a competence of person.

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