# Life-Long Learning: Individual Abilities versus Environment and Means

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**Abstract.** This paper describes new and emerging technologies in education, learning environments and methods that have to satisfy life-long learning of person, from school age to retirement, on the basis of the psycho-physiological model of the cognitive abilities formation. It covers such topics as: evaluation of a human (accounting schoolchildren, youth and adults features) abilities and individual propensities, individual trajectory of learning, adaptive learning strategy and design, recommendation on curriculum design, day-to-day support for individual's learning, assessment of a human learning environment and performance, recommendation regards vocational retraining and/or further carrier etc.). The specific goal is to facilitate a broader understanding of the promise and pitfalls of these technologies and working (learning/teaching) environments in global education/development settings, with special regard to the human as subject in the system and to the collaboration of humans and technical, didactic and organizational subsystems.

**Keywords.** Human abilities, development, learning environment, tools, safety

**Key Terms.** Capability, Technology, PSI-ULO, ICTEnvironment, PSI Core Time ontology

## 1 Introduction

Global changes in education aimed at ensuring tasks to account the transition from the post-industrial to a digital era as well as to the knowledge society when a human individual cognitive and creative ability become crucial for the mankind development [11]. Education needs to be more and more individual-oriented, securing individual psychophysiological abilities and development including network (as a main learning/nurturing environment) security and safety [14, 17].

Going beyond learning time and space constraints has been a crucial motivation. Social, businesses, education/learning actions now take place globally and in many time zones. Human knowledge and intelligence is now being systematically transferred to computers, allowing them (e.g. in the form of robots or automated systems) to operate autonomously even far away from the original time or space of its human

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originators. Moreover, that notation of space has expanded: new spaces have opened up like the cyber space of Internet, cloud education etc.

Giftedness is associated with creativity, cognitive abilities, intelligence and other psychological qualities. To date, challenges to education are associated with modern possibilities, innovative technologies and higher attention to a student ability to obtain knowledge and skills up to date. Using the concept of context-based cognition it is assumed that learner's individual construction of knowledge should take place within a certain context, which is similar to the context in which this knowledge should be applied in the future [3].

At the same time it is known that human cognitive opportunities can vary from day-to-day depending on his/her functional state and fitness-for-work [4, 5]. As a result, such changes can impact a human ability to adapt in a particular learning environment, to perceive and to conceive new information, to use it, to get knowledge and skills and to prevent its inefficiency. Besides, it is known a negative impact of a human's work with computer over a long period on his/her health and mental efficiency nowadays. It is especially important for children and young people whose organism is more sensitive and unstable comparing to adult one. Health disturbances have impact on a child mental efficiency in learning process as a consequence of this. Some of them have fluctuation nature in their development. As a result, efficiency of learning and talent nurturing depend not only on innate child properties, but on information contour of functional system of learning as a specific type of activity.

Difficulties to assess and to predict students' abilities and achievements are result of lack of recognized definition of giftedness and measurement tools [10], accounting actual learning environment [13] and dynamic nature of giftedness and talent development [12].

It was stated that the most fruitful approach to understand mechanisms of activity is a theory of functional systems proposed by P.Anokhin [1] and his disciples (K.Sudakov, A.Navakatikyan) who proposed the concept of the activity functional system that connects in one model physiological systems state, conditions of the work environment and the goal of activity. According to that a human activity is accompanied by creation and maintenance of functional systems that are activated dominant brain structures and correspond activity of one or another organism systems and are quite enough stable for particular type of the human work. But this is not enough to understand to what degree it can explain reasons of insufficient accuracy of a human performance prediction.

The **purpose** of the article is to describe psycho-physiological basis (concept and model) of a human learning process, as well as human view on network-born threats for a human (users of all ages) health and performance.

## 2 Method

The method used is based on the model proposed by the author. This model is a development of the basic idea of P.Anokhin regards formation and functioning of the "functional system of activity" [1].

Any human activity of mental type could be analyzed as an operator work, because professional operator (pilot, power unit dispatcher, driver etc.), manager and learner have to do with the objects indirectly through the information model of process activities. Work (activity) of such a type has specifics consisted, first of all, in a workload, because of not so power-consuming processes, as informational ones that are, by their nature, not so discrete, but continuous [5]. The reason is that the conceptual model of activity (as result of a human psychological adaptation to the work) is expanded in the time independently on external process and an operator activity consists in discrete comparison of the information obtained from outside with the model existing constantly. I.e., conceptual model can be considered as an information stratum of professional work, and physiological chain „afferent inputs – activity acceptor – physiological control – effectors - act" is an energetic stratum. The goal of professional training is forming of the conceptual model of activity of particular type, carrying out of the particular task. It means creation of „information contour" that exists and is maintained in activated state in carrying out process for purposeful activity and embraces afferent inputs, decision making block, activity acceptor and act program, as well as the object of activity (is represented as information model in case of operator-watcher that creates the information contour together with the imagine- conceptual model).

Energetic and information stratums can be represented as two contours which partly coincide at the level of morphological structures and functions, but partly differ because of including into the information contour an activity object that does not participated in the energetic contour of the organism regulation, but is an inalienable part of the information contour. Human activity is a mediator between internal and external environment of organism, projection of structural-function specific of professional homeostasis on the operator work. Output parameters of the activity program (activity effectors) stand in the information contour as parameters of capability. In such a context, operator's activity is an activity program realized as physical and/or mental acts in external environment.

### 2.1 Research Question / Hypothesis

The specific of learning work consists in the informative processes which are more involved than energetic ones, and conceptual model of learning work is a result of psychophysiological adaptation to this activity. This is relatively close to an operator activity and, from substantial viewpoint, consists in discreet comparison of information received from the educating system with the conceptual learning model used, in carrying out a particular task. In other words, in forming and using an „information contour" that exists in active state in the process of purposeful activity (Fig.1). This contour includes afferent inputs, decision making block, act acceptor and act program, as well as the object of acting (information model for operator). This hypothesized model of psychophysiological maintenance of mental activity was developed as an advancement of P.Anokhin's theory of functional systems.

Stability level of circulation in the information loop can be provided by its dynamically fluctuation according to changes in levels of activation of certain physiological systems subject to constant resultant of power. In formalized form, this means that if the index of indicator level of information circulation $i$ (eg, speed) in the information loop is constant (ie, periodic with frequency $\omega_i \rightarrow 0$), mental capacity $R$ is

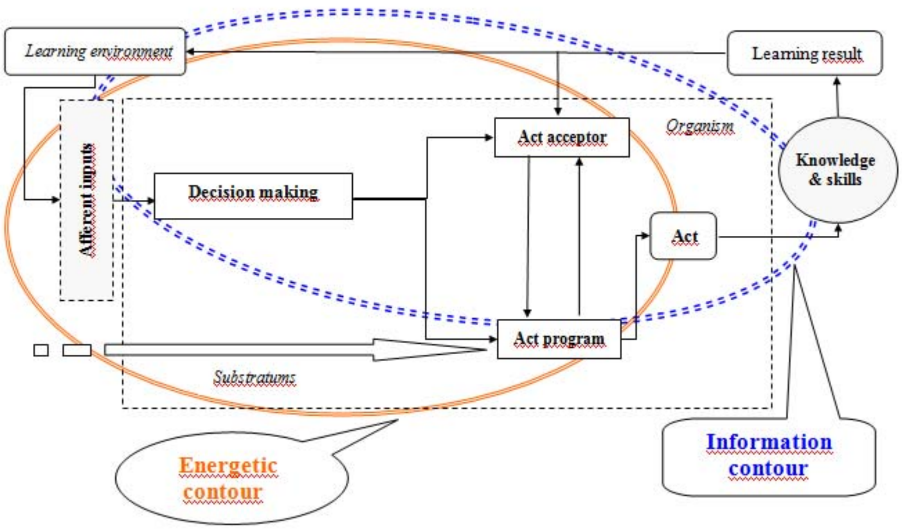


**Fig. 1**. Theoretical scheme of the functional system of learning activity, where regulation (Anokhin, 1973, [1]) was divided into two contours – information and energetic ones

at one level, and integrated parameters of physiological systems $\varphi_j$ change of characteristic for their frequency $\omega_j$, then

$$F = Af(\omega) = \sum B_j \varphi_j (\omega_j) \approx \text{const},$$

where $A$, $B_j$ - average values of estimated parameters in the range of observation.

Description is given from viewpoint of both theory of functional systems and new "vortical model" of ability development as a dynamic transformation [7]. The latter means that natural inclinations transformation into child ability can involve physiological, psychological and external sources as "developing environment" that create particular abilities as a specific combination of abilities existing only in interaction with actual environment. And this interaction has dynamic nature depending on power and rate of three sources circulation that involve information, knowledge and skills as a catalyst saturating the giftedness structure created.

Afferent inputs correspond to well-known sensory systems and could be divided into:

- visual,
- auditory,
- tactile,
- gustatory,
- scents,
- temperature,

- vestibular,
- kinesthetic.

In such a context analyzers' characteristics are as follows: energetic, informational, spatial and temporal.

### 2.2 Changes of Cognitive Abilities in Day-to-Day Intervals

It was confirmed that human ability to cognitive performance is not stable over time span that impacts on human mental performance efficiency [6]. This corresponds to idea of the central role of cognitive processes in prediction of training and operation. Oscillations of psychophysiological indices of a human state and capacity have exogenous and endogenous nature.

The model can help to answer the following questions: what to measure, assess and predict? Main issues to be accounting in this context are as follows:

- Measurement should be a tool, not a goal.
- Parameters of the information contour should be measured for each stage of a student work:
  - Professional adaptation-dis-adaptation.
  - Day-to-day fitness-for-learning.
  - Current learning performance degradation.

This method and its application regards day-to-day fitness-for-learning are discussed by result of study of 20 intellectually gifted school boys' cognitive abilities on a month day-to-day basis. Subjects participated in two types of observation: (1) preliminary assessment of specific abilities for particular areas of mental activity (math, science, technical etc.), (2) day-to-day monitoring of performance the series of cognitive tasks [7].

The effectiveness of research psycho-physiological techniques considerably rises in case of usage not of a set of tests, but of a psycho-diagnostic system. To solve this task the computer system of psycho-physiological researches of a human psychomotor and cognitive activity in conditions of research laboratories and rehabilitation centers was developed. Experiments included psychological tests performance by subjects at the computer display and simultaneous measurement of physiological parameters. They were used tests as follows: short memory, perceptual (searching of missed numeral), cognitive (logic-combinatorial) [2]. In all tests we registered time of each task performance in milliseconds, correct (expected) and really entered answers. Besides, we used a subjective state assessment of the examinees by means of the reduced variant of the test "General_state - Activity – Mood" (GsAM) at the beginning and at the ending of the test session. (the indices of mood mood, serviceability FfD, attention atten, anxiety anxiety) prior to the beginning (index "0") estimated and upon finishing the tests performance.

As indices of physiological "cost" of activity and the human state we registered a heart rate HR and blood pressure (systolic BPs, diastolic BPd) by means of the cardiomonitor "Solveig". The indices HR, BPs and BPd we registered during 5 min prior to the tests beginning (index “0”) and 5 min after finishing (relaxation).

The specific of the research technique consisted in to check the variability in time of psychophysiological indices registered when subjects performed cognitive and perceptual tests, under impact of infradian rhythms of a various origin. Each examinee took part in experiments with constant workload in the same phase of day to eliminate the circadian effect.

The data on influence of solar activity on a human health and some physiological systems are known, however results of study of cognitive activity associating with heliophysic parameters are not known in the scientific literature to date. In our preliminary pilot researches the precise connection between effectiveness of operator activity and parameters of a solar wind (SW) was revealed. With the purpose to study this phenomenon we registered indices of proton component of a solar wind - velocity SWsp (km/s) and density SWden (proton/sм3) on the data from Internet site NASA [15], as well as parameters of the geomagnetic field (GMF) - planetary index Ks and index of “equivalent amplitude” A.

Average values of physiological parameters testers for testing days indicate the individual character of their dynamics as in the initial state (immediately after school) and after the test activity. Comparison of changes in the nature of physiological parameters as a reaction to stress (cognitive tests are simple and conform to the logical skills of Grade 1 pupils of secondary school), indicates that even these activities can serve as a functional test of the occurrence of fatigue, which was found in previous studies (Fig.2).

It is significant increase in heart rate in the first of the testers, while, as in other myocardial activity is, on average, unchanged. This subjective assessment of mood under the influence of the test after the end is more stable comparing to the original state (just after the last lesson). Thus, different tendencies of objective performance changes, self-assessment and physiological changes in time, under learning and external factors impact need to be accounting as the comprehensive approach in education process to increase its efficiency and to reduce negative its negative impact on students’ health.

### 2.3 Possible Applications of the Model to Control Students Cognitive Performance

Practical realization of these ideas is applied for the cybernetic mechanism of a human performance control. There is the set of psychophysiological parameters of human **P**, which are related to forming and realization of his capacity. The set of his professionally important qualities, parameters of professional senescence and current capacity is a number of the parameters of operator professional activity D. The task of synthesis of the system for psychophysiological prediction of operator capacity is the task of optimum reflection P on D, that provides maximal quality of functioning SLTS Q subject to the system cost C, which does not exceed a possible level Clim: $[p \in P]$ m $[D^* \subset D]$, where m – operation of optimum reflection of elements P on the set of elements D; D* - optimum set of parameters of professional activity

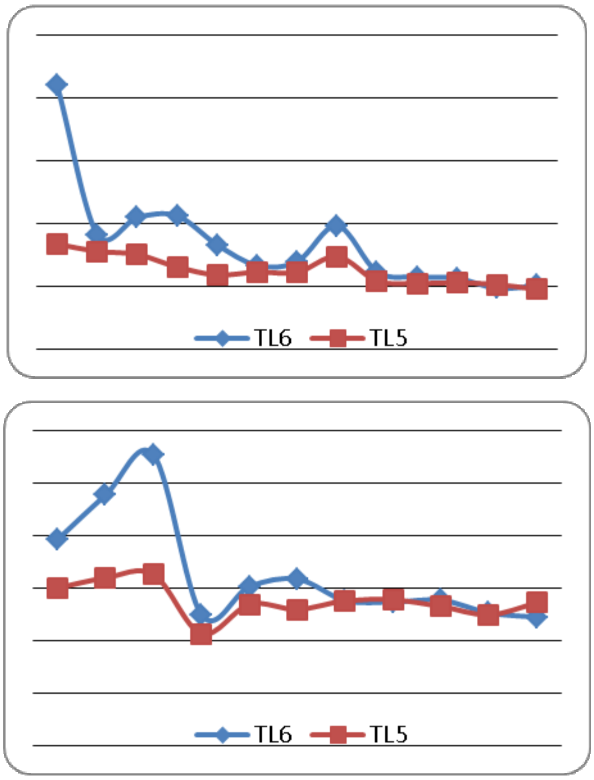


**Fig. 1.** Daily dynamic run-time tests of two subjects. On the axis: abscissas - days of test performance, ordinate - the average task time performance in tests T6 and T5, ms.

$$D_0 = \arg\max_{D0 \in D} Q(D) \text{ under } C \leq C_{lim}.$$

Notion "control" is used as a process of adduction of the set object in the state, that answers the task put. Such determination allows considering the capacity of operator as an object of control by organizational-psychological methods, and the system of assessment and prediction considering as a system of the operator capacity control. In the general case of ergonomics approach to the analysis of efficiency of the system Human-Technique-Environment (SHTE) the estimation and purpose of prognosis of functional state and operator capacity U in SHTE is to provide maximal quality of functioning of the system Q, which relies on the realized of operator capacity R, organization of the system O, the state of equipment E, inter-element interface I, dynamics of SHTE changes in time t. Such task is described as:

$$\hat{U}(t) = \underset{\check{R},\check{O},\check{E},\check{I}}{\operatorname{argmax}}\, Q(t) = \underset{\check{R},\check{O},\check{E},\check{I}}{\operatorname{argmax}}\, f\,[\, R(t), O(t), E(t), I(t), t\,]\,,$$

where $\check{R}(t) \in R(t)$, $\check{O}(t) \in O(t)$, $\check{E}(t) \in E(t)$, $\check{I}(t) \in I(t)$.

If estimation of capacity works for real $\hat{U} \rightarrow U$, quality of functioning SHTE can achieve the maximal value $Q > Q$ max thanks to the use of maximal operator capacity.

It was developed the system to optimize students' work with computers in regards to choose optimal form of learning for a particular moment with advanced proposals for a student that gave flexibility of work in particular day accordingly to his/her functional state (to take lectures, to work in interactive mode with computer or teacher, to make applied tasks, to work in library, to work in Internet etc. or to delay an active form of teaching for another time). This could give a tool to intensify the education time by way to re-allocate efforts and to optimize a time use.

The physiological mechanisms of the adaptation of a student's activity functional system to the education environment may vary depending on the conditions, location and time of his/her activity. Hence, proposed approach may contribute to improve human working conditions if it takes into account not only macroergonomic requirements (spatial aspect of human interaction with the environment), but also ergodynamic ones (temporal aspect). Direct or indirect measurement of possible psychophysiological changes when learning makes it possible to review a functional state of the student, which helps to predict his/her individual fitness and reliability for effective learning process.

Task performance measures before current learning activity should be focused on rate and accuracy of information processing. The student's test performance, which precedes a work with the computer system, consists in decision of the same type of cognitive and perceptual tasks. The time and accuracy of each task performance are registered. Task performance times produces during research a time series, which consist in sequence of values of tasks decision time. The further analysis of time series permits to reveal the "waves" that are induced by the regularity of fluctuation of task performance time.

Computer method allows varying flexibly the tempo, volume and complexity of test tasks for different levels of cognitive and perceptual complexity with and without interferences. The research method foresees to investigate and take into account the biorhythms influence on the human behaviour and fitness for duty with periods up to 1 month.

According to schedule a student came to the computerized workplace and performed a cognitive test with the computer sub-system and got as a result a time of his/her effective work with computer for current day. That recommended time could be coordinated with the student's supervisor and a real time could be changed.

Electronic education gives new opportunities such as:

- flexibility of education programs – a student can choose courses, teachers, time of active work, etc.;
- individualization of education process – re-allocate time and education resources in dependence on a student's individual psycho-physiological possibilities to make this process more intensive and to give equal opportunities for both common people and people with disabilities.

This advanced proposals can help a student to make a decision what type of work in particular day is preferable accordingly to his/her functional state:

- to take lectures,
- to work in interactive mode with computer,
- to work in interactive mode with a teacher,
- to make applied tasks,
- to work in library,
- to work in Internet,
- to perform individual tasks etc.
- to delay an active form of teaching for another time.

Although further work is required to gain a more complete understanding of such a tool's use, it is clear that this could give a student an opportunity to intensify a time by way to re-allocate his/her effort and to optimize a time use. The main idea of such approach is "Don't waste a time !". Another aspect of the same problem is an adaptive automation of human-computer interaction in accordance with a student functional state.

The current study provides further evidence that traditionally education managers do not analyze such opportunity to make the education process more effective, because a student must study as it is done. This way is aimed to a "group norm", but not to an individual, especially gifted and talented.

## 3 Networking Threats

As it was stated [14], not so far ago a human place and role in networks could be described as a terminal element (node) linked to other elements with its specific interface (having human and technical parameters). Currently, when a human life and activity has more virtual nature, information environment (network) becomes independed factor, because process of a human presence as well as results of his/her activity loses their localization in space and in time, as well as could be affected at anytime and anywhere. Even more, those results could «live» inside the network «infinitely», because technical resources holding them are distributed, flexible and supported continuously.

Recommendations for improving a human psychophysiological security have been developed and described [5]. The further development of ergonomics criteria could be developed accounting the new human activity nature and a multiaspect ergonomic analysis [16, 18].

Active usage of networks, especially by children and youth, is accompanying by increase of different kind of threats coming from networks. Particularly acute this problem obtained with development and use of social networks. Most active hidden threats (for children) emanating from the computer network, stacked in the following classification scheme [8]:

- Viruses attacks.
- Cyber-crime (spamming, carding, phishing, botnets etc.).
- Threats from network-surfing (cyber-bulling, "adult" content, illegal content, online violence, disclosure of private information, pay services etc.).

It is recommended considering the interaction between schoolchildren and students with computer network as the system "Human-technique-environment" [8]. In this system, computer network serves as a machine that allows us to consider the impact of the network on a human as a threat coming from the machine. Accordingly, the concept of "network effect" can be revealed through the concept of "operator error and reducing the quality of operator activity', 'impact of computer games" and "Internet addiction".

Threats coming from networks can be classified into the following types: active and passive, overt and hidden, current and deferred.

Using ergonomic approach and methodology, it is possible to evaluate active hidden dangers as a hierarchical set of indicators:

- one integrated (complex) index - the level of danger as a result of a computer network; index is a dimensionless quantity and is on the upper level assessment system;
- group of three indicators - levels of hazards caused by virus attacks, cyber-crime or internet surfing; indicators are dimensionless quantities and are at average levels of the system assessments;
- a set of individual indicators of the group of one or set of threats; indicators are also dimensionless quantities and are on the lower level grading system.

From educational domain context, target groups of CS could be classified as follows:

- Students as operators
- Educators
- Children/Yourth (in general)
- Population (in general, as social environment for children).

The human view regards CS could be a fruitful approach to define tasks, resources and ways of solution the above mentioned challenges [8].

*Human View – constraint*.

If a system requires a human interface, then the system must be designed to accommodate the human as a passive and as an active element, creating sub-system for safety both for and from a human.

*Human View – functions*.

Provide a justification for the allocation of tasks and functions between the humans and machines depending on a human current status and capability.

*Human View – role*.

Describes the roles that have been defined for the human interacting with the system and their possible changes over mission time (f.e., from simple executor to leader and/or commander) accounting his competencies, ability for tasks generation, leadership etc.

*Human View - human network*.

Team performance impacts, re-allocation, dependencies and communication.

These views should be a basis ergonomically grounded for design and creation new and safety educational tools.

## 4 Conclusions and Outlook

Digital life and activity gives new opportunities for people and new problems in different domains including education.

Broader understanding of the promise and pitfalls of learning technologies and working (learning/teaching) environments in global education/development settings could be useful with special regard to the human as a subject in the system and to the collaboration of humans and technical, didactic and organizational subsystems.

Global changes in education aimed at ensuring the transition from the post-industrial to a digital era as well as to knowledge society when human individual cognitive and creative abilities become crucial for the further development of mankind.

Psycho-physiological model of learning and cognitive abilities development could be a basis for more effective design of learning organization and process.

They are proposed to discussion: identification of areas in which coordinated research efforts are required to expand an understanding of these network technologies, their effectiveness, the potential risks, and the potential benefits of new ways to educate, learn and collaborate.

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