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INTERDISCIPLINARY EDUCATIONAL TECHNOLOGY BASED ON THE CONCEPT OF HUMAN BRAIN FUNCTIONAL ASYMMETRY

Alexander Voznyuk[1], Sergey Gorobets[2], Serhii Kubitskyi[3], Victoriia Domina[4], Natalia Hutarieva[5], Maxim Roganov[6], Ihor Bloshchynskyi[7]

[1] Department of the English Language and Primary ELT Methodology, Zhytomyr Ivan Franko State University, 10008, Zhytomyr, Ukraine
E-mail: alexvoz@ukr.net, orcid.org/0000-0002-4458-2386
[2] Department of Applied Mathematics and Computer Science, Zhytomyr Ivan Franko State University, 10008, Zhytomyr, Ukraine
E-mail: sgs_cat@yahoo.com, orcid.org/0000-0001-7639-9714
[3] Department of Management and Educational Technologies, National University of Life and Environmental Sciences of Ukraine, 03041 Kyiv, Ukraine
E-mail: kubitskiy@ukr.net, orcid.org/0000-0002-7691-8606
[4] Department of English Philology, National University of Life and Environmental Sciences of Ukraine, 03041 Kyiv, Ukraine
E-mail: domina@nubip.edu.ua, orcid.org/0000-0002-3308-1754
[5] Department of Medical and Biological Fundamentals of Life Protection and Civil Protection, State Higher Educational Establishment "Donbas State Pedagogical University" 84116, Sloviansk, Ukraine
E-mail: nashkaf@ukr.net, orcid.org/0000-0002-4635-61064
[6] Department of Pedagogy, National University of Life and Environmental Sciences of Ukraine, Ukraine, 03041 Kyiv, Ukraine.
E-mail: maxipro1987@gmail., orcid.org/0000-0001-6488-8692
[7] Doctor of pedagogical sciences, professor,
Foreign Languages Department, Bohdan Khmelnytskyi National Academy of the State Border Guard Service of Ukraine, Khmelnytskyi, Ukraine
E-mail: i.bloshch@gmail.com, orcid.org/0000-0003-1925-9621

Abstract
The main aspects of interdisciplinary technology of educational process based on the concept of functional asymmetry of the cerebral hemispheres, which reflect space-time asymmetry of the Universe and constitute a certain psychophysiological focus of human organism, are presented in the article. Its urgency stems from the global tendencies, evolving towards the information society (or the "society of knowledge") and influencing the development of education, becoming increasingly multimedia-rich and psychologised. The authors consider the major peculiarities of cognitive strategies of brain's hemispheres, which should be taken into account in educational process with a wide use of multimedia means when teaching different academic disciplines. It is shown that training materials offered to the students can be differentiated by the right (abstract and verbal) and left (concrete and graphic) video sequences, which corresponds to hemispheric information processing strategies and promotes the synergetic state of synchronization of the hemispheres functions. Meanwhile, the encephalographic studies show that such functional synchronization, revealing the specific state of human brain, presupposes the integration of two information processing strategies,

leading to harmonization of the processes of the first and second signalling systems. The algorithms of the most effective influence of multimedia presentations of teaching materials on a student based on the concept of functional asymmetry of human brain have been substantiated. These algorithms provide for combining the "left" and "right" information in such a way that the volumes of two types of information would form a harmonious (golden) proportion.
Key words: *multimedia technology; hemispheres of human brain; synchronization of hemispheric functions; educational process; synergetic.*

Introduction

Formulation of the problem. A characteristic trend of the postmodern world is globalization, hyper-communication and the continuous growth in the amount of information when all aspects of public life are exposed to information technologies that replace the crucial features of culture. Today science no longer sets the agenda for technology; "technoscience" is the driving force of information technology as defining the mode of economic production in culture and society (Oliver, 2006). It boosts the change in technology, thus enhancing the role of the personality by intellectualizing their activity. This, in turn, requires a qualitatively new level of teaching the students both basic and professional disciplines, ensuring intellectual, psychological and moral readiness of all participants of the educational process for the work in new environment.

The Laws of Ukraine "On the National Program of Informatization", "On the Basic Principles of the Development of the Information Society in Ukraine" determine the strategy of solving the problem related to provision of information support in all spheres of human activity, when educational informatization is to be directed at formation and development of nation's intellectual potential, improvement of the forms and content of educational process, the introduction of computer teaching and testing methods directed at solving different educational problems in the context of the postmodern challenges of socio-economic and environmental character.

Since the new socio-economic conditions require the use of the particular means of educational process management, therefore, scientists make purposeful attempts to modify the functional use of computer technologies on order to reveal their real impact on the process of education.

All-rounded analysis of current socio-cultural situation in Ukraine and in the world as well as the recent studies in the field of education enable one to come to a conclusion that a new computer-oriented paradigm of educational process is developing based on the phenomenon of exponential growth of scientific knowledge and widening of the interdisciplinary researches.

General Background of Research

Analysis of recent research and publications. Didactic aspects of designing computer tools have been developed, determining the effectiveness of the use of computers in educational process. In this context we can mention general pedagogical aspects of usage of computer oriented technologies, namely of Anki specialised application during foreign language professional training, investigated by I. Bloshchynskyi (Bloshchynskyi, 2017). Didactic aspects, as well as computer functions in educational process investigated by M. Karpushyna, I. Bloshchynskyi, V. Zheliaskov, V. Chymshyr, O. Kolmykova, & O. Tymofieieva, are revealed in their works dealing with the training and using specialized computer programs to intensify the learning process of military specialists at different specialties (Karpushyna, Bloshchynskyi, Zheliaskov, Chymshyr, Kolmykova, Tymofieieva, 2019; Bloshchynskyi, 2017). In the postmodern society an important condition for successful professional training of the specialists of any profile presupposes wide use the information-computer technologies, including the use electronic educational software and multimedia.

In the postmodern era, the basic foundations of the human soul also fluctuated. They testified to the complex and contradictory processes of reassessment of the axiological reorientation of modern personality. In this case, scientists S. Hanaba, O. Mysechko, I. Bloshchynskyi emphasized that solidarity of efforts is a common condition for the survival of the world, a prerequisite for trying to restore coherence in the life systems of the planet, eliminating the carcinogenic source of inconsistency in self-centered individual and collective human behaviour. (Hanaba, Mysechko, Bloshchynskyi, 2020).

Catalina M. Georgescu revealed the problem of identity and realization of European values in the media using a postmodern methodology (Georgescu, 2018). Noteworthy is the research on the transformation of values and the mentality of young people under the influence of cultural diversity (Pehoiu, 2018). An example of practical implementation of our theoretical considerations is a study conducted by the scholar Claudia Salceanu, who conducted a comparative analysis of the value system in society between different generations of people, showing the possibilities of building paths of tolerant environment and coexistence of different generations (Sălceanu, 2019).

The methods of using computer-oriented technologies by the students on "Nursing" specialty were investigated by Melnychuk, Rebukha, Zavgorodnia and Bloshchynskyi (Melnychuk, Rebukha, Zavgorodnia, & Bloshchynskyi, 2018). The principles of the use of information and computer technologies, namely the use of electronic educational and methodological software packages in teaching different disciplines were described by I. Bloshchynskyi, O. Halus, I. Pochekalin, and D. Taushan. (Bloshchynskyi, Halus, Pochekalin, Taushan, 2018).

Obviously, preparing and delivering lectures in this format requires of the lecturer not only to be able to work with the computer equipment and appropriate software, but also the knowledge of the peculiarities of the perception of training information by the students, as well as the general principles of composition of video sequences. However, these issues have not been sufficiently covered in scientific literature. In this regard for enhancing the effectiveness of the perception of educational information, it seems relevant to dwell on some effective ways of presenting educational information using the capacities of computer graphics and the functional asymmetry concept of human brain.

Methodology of Research

The objective of the article *is* to substantiate an interdisciplinary technology of educational process based on the concept of functional asymmetry of the cerebral hemispheres of human brain.

In order to reach this goal, we have conducted our research on three methodological levels: 1) general/overall (general principles of the concept of functional asymmetry of human brain), 2) peculiar/specific (this concept is analyzed in the context of human perception of training information) and 3) single/individual (the major principles of such perception are used in grounding and working out of certain algorithms of the most effective influence of multimedia presentations of teaching materials on a student).

Results of Research

Methodological level of the general/overall

In our changing time, one can be a witness of radical transformation of educational technologies, which begin to focus on the achievements in the field of psychology. One of the new direction in pedagogical science is a called “psycho-pedagogy”, which uses widely different psychological data, namely functional asymmetry of human brain.

Functional asymmetry of human brain is one of its most pronounced features reflects the difference in distribution of neuropsychic functions between its left and right hemispheres. The existence of such an asymmetry was discovered in 1836 by a rural doctor M. Dax, who established a correlation between the damage of the left hemisphere and the loss of speech in

40 patients. In 1981, R. Sperry showed that each of the hemispheres plays a leading role in certain psychic functions of a human. (Sperry, 1968).

As numerous scientific experiments show that the brain's hemispheres play a very important role in human life (Simonov, 1991). Although both hemispheres are interrelated and function in interchangeable way each one introduces its own characteristics into the work of the brain as a whole. The left hemisphere participates mainly in analytical processes, operates with discrete concepts and sequences of separate symbols. Contrary, the right hemisphere works with integral constructions, with sensory images, providing a holistic, analogous description of the world. That is why the left hemisphere can be called logical, and the right hemisphere – an imaginative one. The psychological peculiarities of the hemispheres, which are to be taken into account in educational process, are presented in Table 1. compiled based on the data taken from various sources (Amunts, 2010; Flor-Henry, 1978; Simonov, 1991; Springer, 1997; Russel, 1991).

Table 1. The psychological peculiarities of the hemispheres

LEFT HEMISPHERE	RIGHT HEMISPHERE
The strategies of cognition and mastering the world	
• Discrete, analytical, classification, abstract, algorithmic, step-to-step thinking • Accurate, monosemantic linguistic and motivation context of cognition and mastering the world The result of such cognitive strategies: the formation of an internally consistent model of the world that can be consolidated and unambiguously expressed in the words or other conventional signs	• Visual-figurative, intuitive, creative thinking • Uncertain, polysemantic linguistic and motivation context of cognition and mastering the world The result of such cognitive strategies: a holistic perception of the world
The peculiarities of incoming information processing	
• Consecutive processing of incoming information with the help of verbal-sign systems with the involvement of facts, logic, realized on the basis of the second signalling system.	• Simultaneous and holistic processing of information, realized on the basis of the first signalling system.
Visual-spatial-time perception	
• This hemisphere differentiates the faces, if they differ only in one feature. • This hemisphere better distinguishes few clear details of the images. • It prefers to break holistic images into parts, details, discrete elements. • The right vision field is the domain of the left hemispheric functions. • This hemisphere is oriented to the future time.	• This hemisphere distinguishes the faces if they differ not in one but in many features. • This hemisphere is good at distinguishing the curvature of lines, irregular shapes, polygons, the spatial arrangement of complex shapes, the depth in stereoscopic images. • It integrates the elements in complex configurations. • The left vision field is the domain of the right hemispheric functions. • This hemisphere is oriented to the past time.
The abilities and activities the hemispheres are directed at	
• This hemisphere realizes speech activity – its understanding and construction, thus working with verbal symbols. • This hemisphere realizes the ability to read,	• This hemisphere realizes the ability to visual and tactile recognition of the objects. • This hemisphere realizes the ability to music and drawing, distinguishing the voices

write, count, analyze, classify, establish cause-effect relationships between the objects and phenomena of the world. • This hemisphere realizes the intelligent interpretation of human sensations, on the basis of which a man develops a certain line of behaviour. • This hemisphere realizes the capacity to select the goals and predict the outcome of own actions.	and emotional states of the interlocutors, expressing and conveying the emotions by voice intonation. • This hemisphere makes it possible for a man to navigate in space and have an accurate idea of his/her body in its movement. • This hemisphere realizes the ability to dream and fantasize.
Types of perceived information	
• Verbal, abstract, rational.	• Non-verbal, figurative, irrational.
Sensory peculiarities	
• This hemisphere realizes the processes of second signalling system. • This hemisphere prefers to percept cold colour spectrum. • This hemisphere prefers to percept rhythm. • The right part of human body is the domain of the left hemispheric functions.	• This hemisphere realizes the processes of first signalling system. • This hemisphere prefers to percept hot colour spectrum. • This hemisphere prefers to percept tune. • The left part of human body is the prerogative of the right hemispheric functions.

Methodological level of the peculiar/specific

The encephalographic studies show that functional synchronization of the hemispheric information processing strategies takes place in a meditation state, enabling a man to actualize the state of illumination, intuitive cognition, resulting in integral perception of the world as a certain wholeness (Murphy, 1985). The functional coherence of the hemispheres (realized in the sphere of "super-I", according to P.V. Simonov (Simonov, 1991), the "compromise" between them leads, to equalization of spatial deformation, that is, to adequate perception of volumetric space characteristics on the retina plane of the eyes, when the volumetric and plane aspects, being geometric antagonists (being demonstrated by the dichotomy of Euclidian geometry and N. I. Lobachevsky's geometry) are harmonized to a common sensory "denominator".

So, the schemes of spacio-temporal organisation of the Universe and human's perception of space and time reveal a direct correlation. Below is the example of such a correlation and a model of functional localization of human brain (Simonov, 1991), which fully corresponds to the oriental symbol of Tao.

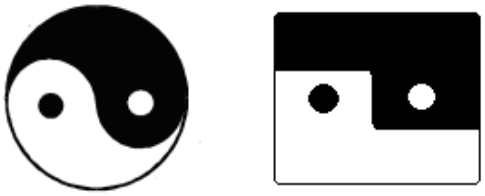

Fig. 1. The correspondence of the human brain functional localization model to the oriental symbol of Tao

In this respect, we can see that each hemisphere controls the opposite part of the body when, for example, the left ear functions are processed by the right hemisphere, and the right ear – by the left hemisphere (Voznyuk, Manolov, 2019; Voznyuk, 2018).

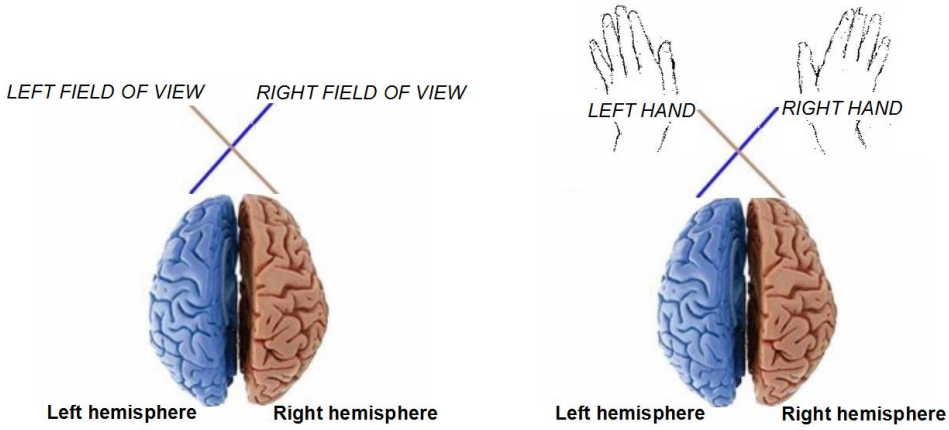

Fig. 2. Inversion perception by the hemispheres of the environment spatial characteristics

Educational extrapolations: the methodological level of the single/individual

Psychologists S. Chyrchyk and D. Charman have found that the perception and assimilation of learning information by a student is greatly influenced by the form of presenting this information. In particular, shape, colour, size, structure, dynamics of the visual image are of great importance (Chyrchyk, 2016; Charman,1981).

It is needed to note that the human brain is not only able to work with two ways of presenting information, but is also able to correlate these two ways, making transitions from one representation modus to another, working with images more efficiently than a computer. In this context, the main problem and task of computer graphics is the creation of such models of presentation of knowledge in which a person could equally reflect and perceive the objects that are characteristic of logical (symbolic, algebraic) thinking, and the objects being characteristic of imaginative thinking.

Illustrative and cognitive functions of computer graphics

Nowadays, the educators distinguish illustrative and cognitive functions of computer graphics. The illustrative function allows us to embody what is already known in the most adequate visual design that is, what already exists in the material world, or exists as an idea in the thoughts of a person. And the cognitive function of computer graphics is directed at receiving something new (that is, something that does not even exist in the mind of a specialist), or, at least, to contribute to the intellectual process of creating new knowledge.

Today we can note the tendency to shifting the emphasis on the use of computer graphics capabilities. An illustrative function is replaced by a cognitive function, which allows activating the innate ability of the human brain to think with complex spatial images, although sometimes the differences between illustrative and cognitive functions of computer graphics are rather relative. In some cases, the graphic image, presented in the form of illustration, can contribute to the birth of a new idea, thus the illustrative function of the computer image transforms into a cognitive function.

On the other hand, in the process of cognizing the properties of an object, the cognitive function of a graphic image can be transformed into an illustrative one.

Interactive cognitive function of computer graphics

However, the fundamental differences in the logical and intuitive mechanisms of human thinking, and, as a result, the differences in the forms of presenting the knowledge and

the ways of its perception, make useful in the methodological sense the isolation of illustrative and cognitive functions of computer graphics (Fig. 3).

Such differentiation allows formulating didactic goals more clearly to use the images created by computer graphics algorithms in the development of multimedia learning technology. ***Illustrative functions*** of computer graphics are most often implemented in technology teaching, which operate with information of the declarative type. Typically, such information is provided in the form of static or dynamic graphic illustrations.

The ***interactive cognitive function*** of computer graphics is manifested in the application of multimedia learning technology, which operates with information of the procedural type, that is, the students acquire specific knowledge in the process of studying the behaviour of an object or process, given by its mathematical model.

The use of computer graphics in education

It is important to note that varied tools of computer graphics reveal wide possibilities for the teacher to create, arrange and re-arrange new educational graphic and text material. Drawing and layout of computer programs provide simple and quick creation, editing, replication of educational material. For example, such popular graphic editors as *Adobe Photoshop, Adobe Illustrator, Corel Draw* have a wide arsenal of tools allowing to change not only the shape, but also the colour palette of the illustrative material. This can be illustrated by Figure 3, compiled by us.

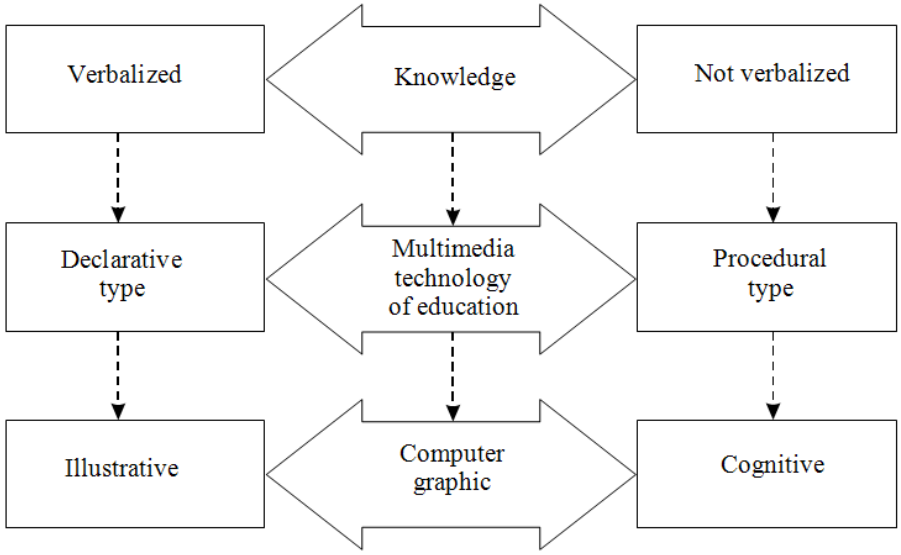

Fig. 3. Genesis differentiation of illustrative and cognitive functions of computer graphics

Various online colour scheme constructors (for example, *colorscheme.ru; color.adobe.com*) help in the selection of a harmonious colour palette by using special colorimetric circles. Herewith, the selection of illustrative material can be carried out on the principle of contrast, triad, tetrad, analogy or accent-analogy. Thanks to the use of colour scheme constructors, an educator who does not have a special artistic training will be able to bring the colour gamut of the prepared illustrative material to a harmonious form, which will improve its perception by students.

More opportunities for improving the perception of educational material are provided by the technologies enabling to create animated images. The editors such as *Animatron, Sparkol, Adobe After Effects* provide the possibility to design dynamic sequences of varying

complexity according to certain scenario. The metamorphosis in the frame allows one to more flexibly control the accents in the composition, clearly illustrate the qualitative changes in the displayed object. The use of transformation of graphic images enables to attract and retain the students' attention, increasing emotional impact on them, thus increasing the effectiveness of mastering the educational material.

The perception of animation and metamorphosis of visual images require concerted work of both hemispheres of the brain, which generates the effect of synergistic convergence of the hemispheric functions of the brain.

Thus, the knowledge of the peculiarities of the perception of information stemming both from functional asymmetry of the cerebral hemispheres, and the use of powerful computer graphics tools in creating lectures in the form of multimedia presentations, contribute greatly to improving the perception and mastering the educational material.

Jibbson's law of right-side stimulation

The principles of hemispheric asymmetry can serve as the basis for building the effective strategy of teaching different disciplines. It has already been mentioned that numbers, letters, words, symbols are better perceived by the students when they are presented in the right field of vision, while concrete objects, image information – when presented to the left field of vision. It should also be noted that the right hemisphere is aimed at perceiving the melodic aspect of musical and verbal information, and the left hemisphere prefers its rhythmic pattern. Thus, the words and, in general, all verbal and non-verbal information can be analyzed from the point of view of its belonging to the "right" or "left" information. In this case, the hemispheric asymmetry reflects the general asymmetry of space and time in our Universe.

Thus, the view of a person usually moves in the process of visual reflecting a particular object from left to right, and space in the same trajectory increases the height of the objects that fill this space, as well as objects' number and compositional complexity increase. This peculiarity is known as "*Jibbson's law of right-side stimulation*", which is applicable to all forms of life on Earth. For example, the first living organisms that appeared on our planet, which lived on the stones of warm oceans, ate these stones spirally, from left to right, and the spiral of their trace was built on the basis of the golden section.

So, in order to activate the cognitive and thinking activity of the students, it is necessary to harmonize the work of both hemispheres taking into account the psychological peculiarities of their functions. For this purpose, the verbal educational information, the perception of which is based on abstract-logical thinking of the left hemisphere, must be combined with graphic images, which helps to use the right hemisphere and makes the perception of studying material by the students more holistic and thus more clear. In turn, this will promote their fuller and deeper understanding of the essence of new information and its translation into long-term memory.

So, in the process of receiving information through the visual channel, visual images of the right field of vision are processed in the left hemisphere and vice versa (Amunts, 2010; Flor-Henry, 1978; Springer, 1997).

This peculiarity is to be taken into account by the educators when preparing explanatory illustrations and slides: the dividing of visual field into the left (figurative) and right (verbal) parts is needed. Accordingly, the delivery of imaginative information is best done on the left side of the slide, and the letters, words; numbers are to be placed on the right side.

Generally speaking, the hemispheres of human brain, which are its "psychosomatic focus," reveal a rather simple sensory-cognitive pattern of perception of the world, when "the continual" aspect of the world is perceived mainly by the right, and "the discrete" – by the left hemisphere.

Shatalov's pedagogical system

It should be noted that the state of human creativity involves the functional harmonization of hemispheric strategies, which in the normal state tend to dominate one another (Russel, 1991). Therefore, the synergistic combination of hemispheric strategies of cognition and mastering the world involves the combination of visual and abstract (verbal) aspects in one context of the material proposed for the students. This method of integration of hemispheric strategies in education process is illustrated by V.F. Shatalov's highly effective pedagogical system, which uses the principle of hemispheric synthesis, when in the educational process two aspects of human psyche are brought to harmony – the right (concrete) and the left (abstract) ones. Due to Shatalov's pedagogical system, the students, on the one hand, receive various concrete facts (mathematical, historical, geographical, etc.), and, on the other hand, all these facts are translated into the language of the reference signals, which are abstract categories. The students are taught purposefully and regularly to manipulate simultaneously with two opposite types of information, realizing their mutual transformation, when the concrete is perceived and understood through the abstract and vice versa. Sufficiently long practice of bringing to functional unity of the right and left sides of cognition activities contributes to the development in the students the psychological attitude for holistic mental activity, within which the desire for creativity is manifested and, as a result, the educational activity is significantly intensified.

From the point of view of functional asymmetry concept of human brain, the combination of powerful computer graphics resources together with the reference signal method is an effective means of presenting the educational material.

Conclusions

So, the teaching information being delivered to the students can be differentiated on the right (verbal) and left (figurative) visual fields, which corresponds to the hemispheric strategies of information processing and promotes the ***synergistic effect*** of convergence of hemispheric functions. On this basis, the algorithms can be highlighted both for effective (harmonious) pedagogical influence of information and computer means, and for creating harmonious (genius) works of art.

For the purpose of meditative-spiritual influence of a multimedia presentation of teaching information (or the work of art) on a student due to simultaneous affecting both hemispheres of the brain and thus synchronizing their processes, it is necessary to combine the "left" and " right" information in such a way that two hemispheric strategies would "extinguish", compensate each other (since the hemispheres functionally synchronize in a meditative and creative state being the highest level of human activities and the sublime aim of human development). Sensory and cognitive peculiarities of hemispheric functions, such as direct and reverse visual perspectives, the perception of colour (cold and hot spectrum), sound (rhythm and melody), discrete and holistic organization of visual information, etc. should also be taken into account.

The two variants of compensating algorithm include simultaneous influence on a person with "right" and "left" information, being equalized, thus eliminating each other; and the influence of "right" information on the "left" hemisphere and vice versa; for example, the visual information which is placed in the left field of vision (where the information is perceived by the right hemisphere) is placed in the right field of vision corresponding to the spatial perception of the left hemisphere – thus we interchange the fields of vision creating the mutually compensating ("annihilating") effect.

For the purpose of harmonizing influence of a multimedia presentation of teaching information (or the work of art) on a student due to simultaneous effecting both hemispheres thus harmonizing their work, it is necessary to combine the left and right information in such a way that the volumes of two types of information would form a harmonious proportion (in the language of mathematics such a proportion is known as a golden ratio, or golden mean).

The optimal ratio is calculated due to taking into account the sensory and cognitive peculiarities of hemispheric functions that enables to achieve the best correlation between the aspects of sound – rhythm and melody (in case when multimedia presentation includes the use of a sound track), as well as between the number of visual elements on the right and left visual fields (revealing the index of visual diversity that reflects not only the number and size of visual elements but also the number and size of discrete and continuous geometric shapes being selectively perceived by the "continuous" right and "discrete" left hemispheres), the colour saturation of the visual elements and the background of visual fields, the parameters of visual perspective.

The prospects for further research lie in developing the holistic interdisciplinary technology concerning the presenting of teaching information by multimedia means based on the functional asymmetry concept of human cerebral hemispheres. The holistic interdisciplinary technology presupposes the mathematical calculation of the golden ratio mentioned above. This may be a new step to developing the information society in the context of developing the educational process being aimed at accomplishment of a new – synergetic and holistic – paradigm of education.

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