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PERCEPTION - OPERATING SCHEME PECULIARITIES AND VISUAL IDEAS IN CYBERNETIC ASPECT

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Abstract: *The article studies the application of the problem-productive strategy in the education in mathematics for Grades 1 – 4. Different options for its application are presented during which the students use cognitive, modelling and technical productivity. As a result of the use of a problem-productive strategy the students acquire knowledge, form skills and develop mathematical competency. They are put in active position and develop such qualities like creativity, observability and critical assessment.*

Keywords: *problem-productive strategy, cognitive productivity, modelling productivity, technical productivity, mathematical competency*

Thinking takes part in the skill. The very semantics of the term means some activity to be performed (something to be done) with a mind. Objects of analysis are peculiarities of thinking through which it manifests itself in the ability to solve problems.

In this publication we will look at those peculiarities of the sensory knowledge that characterize the manifestation of thinking in the ability of solving problems.

1. Perceptions form the basis of cognitive activity. Simultaneousness of thinking in problem solving

The reasoned conception about skills of B. Minchev (Minchev, 1991) assumes that forming of skills depending on a particular situation initially is a perceptual phenomenon and secondary situations are experienced in memory, thinking and imagination. Following Gestalt-psychologists, it is assumed that the latter three functions to a great extent are derivatives of perception and are bearing the quality of its structuring i.e. of the particular situation. In our view, in didactic terms, one of the most important features of perception is apperception, i.e. perception depends on the subject itself and the reflection of the socio-cultural environment. The richer the experience of man is, the more knowledge he has, the richer his perception is. In support of this thesis is the late appearance of the linear perspective (during the Renaissance) in interpreting the space in the fine arts – the illusory representation of the third dimension in a two-dimensional plane.

Ulric Neisser considers that perception is guided by the premonition, which has a highly integral character. For example, as a result of manifestation of premonitions objects may look solid, heavy and warm without touching them. Manipulation with premonitions is one of the most fundamental operations among the so-called high psychic/mental processes (Naiser, 1976).

Thus, in fact, a major problem is posed: What is the correlation between image structures (that, which is before them) and verbal structures.

What is the correlation between the preverbal and verbal when solving problems and how manageable is the first?

The processing of information by the human brain takes place both through speech, phrases and meaning, as well as through the images, the codes of the signs, the sounds, i.e. simultaneously at verbal and preverbal level. The human thoughts receiving verbal realization and logical form are as if only the visible, above-water part of the iceberg. The human brain has most probably inherited some mechanisms of simultaneousness of thinking, of accelerated information processing.

Of interest is the relation between the underwater and the visible part of the iceberg related to the stages of solution. At the stage of understanding the problem dominates the consciousness. At the stage of finding a solution often crucial role plays the activity of the unconscious, i.e. in these cases the visible part of the iceberg is negligible. At other stages again dominate consciousness. It can be concluded that consciousness dominates in the “intellectual act”, regulates the solution process and the subconscious enters into the quality of the object of regulation” (Druzhinin, 2000).

We will recall the words of the great physicist Albert Einstein that there is no doubt that our thinking is going mainly ... unconsciously. Regarding the so-called “mathematical dream” Hadamard writes: “The phenomenon is trustworthy and I am responsible for its absolute credibility. Evidence is the sudden emergence of a solution at a time of abrupt awakening. Once, when I suddenly woke up from incidental noise, instantly and without any effort a solution to a long-discussed problem had arisen in my mind – the idea of the solution was totally different from all the ones I had tried earlier.” (Adamar, 1970).

From the point of view of the ability to solve problems important is higher level of awareness at the stage of finding a solution for which contributes, for example: the analytical method of reasoning when solving problems (solving from the end); forecasting as part of the prediction, which is of a high level of awareness and verbalization.

2. Separate and simultaneous brain functioning in problem solving

V. N. Pushkin writes that quite likely is the following situation: while the brain unconsciously contemplates one aspect of the problem, simultaneously it can at the same time consciously develop or examine another aspect of the same problem. This he motivates with the existence of a dynamic brain model of the problematic situation that is capable of autonomous work, which in some sense is independent of the conscious activity of man. Once the problem is solved, the results of the functioning of the model as if are passed to the person who solves the problem (Pushkin, 1968). Pushkin seeks support for his hypothesis in the studies of N.A.Bernstien, A.A.Uhtomsky (the creator of the doctrine of dominance), L. C. Krushinsky (who raised the idea of the extrapolation reflex as a particular form of reflection activity), and D. N. Uznadze (who created the part “psychology of attitude” in experimental psychology). For its deployment he cleverly combines ideas from heuristics as a science of creative thinking, cybernetics and in particular heuristic programming.

The above said means that visually operating schemes and visual ideas, the idea of parameterization, the establishment of the credibility of the ideas for solution can work autonomously and simultaneously by interacting and among them there are such ones that amplify the others. Most often the interaction is week. In our view, this is due to the dominant nature of the subsystems where the thinking process to a large extent has acquired a verbal expression. Often the emerging idea of solving a given problem prevents the emergence of other such, i.e. it assimilates them. And something more. When in our training/education we had to use a given already solved by us problem and we try to recall some solutions, suddenly a new solution emerges (without having set ourselves the goal of looking for such).

The crucial problems generally are these from the “direct seeking solution” group (our formulation after a description by Dixon). Let us recall the behaviour of a person who solves a previously solved problem and has “forgotten” the solution.

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In the studies of creative thinking is noted the fact that problems are often solved not at the time when we work on them but at other moments (in the bus, on a trip, early in the morning), i.e. where there is no dominant.

A main manifestation of thinking in the ability to solve problems is the separate and simultaneous functioning in realizing different aspects when solving a given problem, regardless of the conscious work of anyone of them. It seems that subsystems of the ability to solve problems interact and influence between themselves and it is more correct to talk about maximum interaction within the autonomy. The effectiveness of problem solving depends on their differentiation and formation, on the conditions for their autonomous application and full interaction.

The latter seems to be realized through a research approach in solving by using of mutually reinforcing techniques and ideas, by building of variety of ideas when searching a solution or at the final stage of the solution. The possibility for the complete functioning of the set of ideas for solving of a given problem is rooted in the simultaneous and autonomous work of each one of the ideas.

3. Perception-operating scheme peculiarities and visual ideas in cybernetic aspect

When looking at the heuristic aspects of solving problems from cybernetic aspect and in particular the role of the perception-operating schemes (POS), we use data from a chess game study. It has become a touchstone for developing and verification of principles and problems of cybernetics. The chess game turns out to be a superb model of the heuristic activity in problem solving because, on the one side, chess rules are simple but before the chess layer there is a constantly changing situation and he has to develop a new strategy in new conditions all the time. On the other side, the chess game takes place in a huge environment (regarding the possible combinations of the chess pieces on the 64 fields on the chessboard), which is similar in character to the characteristics of the real world, in particular to the problem solving process. On the third side, the chess game can be considered as a complex repetitive situation, i.e. it is appropriate to be analyzed through the situational approach for skill formation.

Another interesting "logic toy" is the bridge game that is probably invented in Russia. At its core is the "O-hell" game, which has very simple rules (it can be mastered for about 20 min.) and is associated predominantly with forecasts.

One of the most extensive researches on the chess game has begun at the International Chess Tournament in 1925, where the world's most famous chess players of the time were present – J.Capablanca, E.Lasker and others. Trusting to some extent the credibility of the results and conclusions in some of the most general psychological studies of the chess game in the period 1894-1963, as well as to the correctness of the methodologies, we can summarize briefly as follows:

Intellect is manifested as a whole and can hardly be analyzed on the basis of its different psychic/mental functions. In the efficiency in chess games playing great differences among people are observed. The difference between the strong and the week is not in the common memory (although prominent chess players can play blind, i.e. game without looking at the chessboard and remembering numerous chess game parties) but rather in the principles of the game and the experience, which have turned to a sense through POS and visual ideas. Intellect manifests itself as autonomous; for example, there is no strong correlation between the possibilities of blind play and the accuracy of prediction. Major transformations are: computation, vision and evaluation. The latter takes place too quickly, as a lightning, and positively correlates with the player's strength. Experiments to study attention and perception between chess- and non-chess players show that they do not differ.

Groot describes an experiment in which during a limited period of time real chess positions are displayed after which the participants are asked to restore the positions of the chess pieces. Chess masters and grandmasters restore 20-24 chess pieces while the beginners only one piece. When participants are offered the same number of pieces but located in a random fashion, the ability of the masters and grandmasters to restore the situation does not differ from that of the beginners (Groot 1966). In our opinion this remarkable experiment clearly demonstrates the immense importance of the image-operational schemes, sensory motor schemes and the integrities created by them. The context of skills and experience is clearly visible. The chess player's memory, attention and perception differ only in the context of his specific chess experience.

In this respect the study of B. M. Blumenfeld, chess master and pedagogue, is of great interest. The main role in decision-making in the chess game performs the so-called "visual ideas" that exist in the head of the chess player. These are ideas of typical connections between the pieces that are formed in the process of gaining an experience. The point is that memorization plays a limited role in the chess player's thinking. The visual idea is a manifestation of past experience that allows sensing the typical connections between the chess pieces in different, changing specific conditions. It is not related to a certain word formulation. Sometimes it is difficult to be expressed in words. Each chess player has a large number of such ideas that make up the basic form of his experience (cited after Pushkin 1968).

Problem 1. How many triangles are there on the drawing?

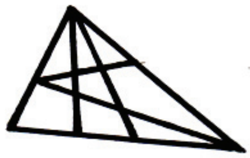

Fig.1

Finding a solution: Let us try to count systematically. Let us consider whether we can through consecutive overlay, starting from the top, count and number in order to be able to compare and improve the counting strategies. Let us look first at the top of the drawing by covering the rest of it with a hand (see Fig. 1.1.1). We count and number the triangles in it in two ways (Fig. 1.1.2 and Fig. 1.1.3).

Fig. 1.1.1

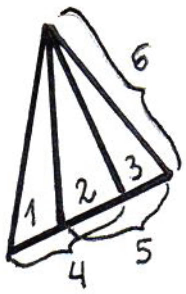

Fig. 1.1.2

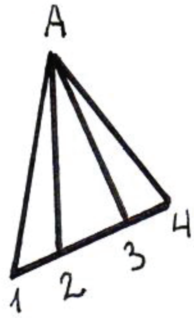

Fig. 1.1.3

By consecutive overlaying the figure we find it in the drawing three times (Fig. 1.2.1, Fig. 1.2.2 and Fig. 1.2.3)

Fig. 1.2.1

Fig. 1.2.2

Fig. 1.2.3

Fig. 1.2.4

Fig.1.2.5

We also find that there are two more shaping figures (Fig. 1.2.4 and Fig. 1.2.5) of the type (Fig. 1.3.1).

Then we get the total number of triangles in the drawing as follows. For a complete combination we can use a model (Fig. 1.3.2), where the intersection points of the segments are indicated by the letter *A* and the numbers from 1 to 9.

Fig. 1.3.1

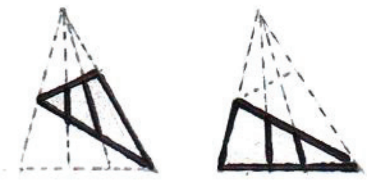

Fig. 1.3.2

Here the visual idea is on the basis of a heuristic solution with a low degree of verbalizability. Its occurrence can to a certain extent be described by the text below.

Here is how Blumenfeld describes the way the visual idea works: In the process of thinking the visual idea usually “emerge” as if automatically. Of course, “emerge” not all of the vast number of known ideas but only the “candidates” for the preconditions of the solution, i.e. those that have or may have relevance to the perceived situation and to the solution of the problem that dictates the situation. In other words “emergence” is not about a reaction of an automat but about automated components of the thought process (again there, p.52). By this description a very important issue is posed – what are the mechanisms of formation and emergence of visual ideas in thinking when solving problems? One issue that even at the modern development of science is difficult to answer.

Some explanation can be found in the work of Boyan Lalov “Extrapolation theory of training/education”. The author explains these processes with the predictive function of the nervous system, which arises from its fundamental property to perform interpolation, i.e. filling the missing information about the images, their likely behaviour and the ways in which the body can react to these images. The accumulation of large number of such predictive relations allows for a new situation to be multidimensionally perceived in future due to the fact that one or other figure combinations can be perceived as familiar integrity images together with the possibilities arising from the mutual arrangement of the figures, dangers and advantages” (Lalov, 2003).

A key thesis is that in order to form a complete system of predictive relations, it is necessary to play “a variety of variants that cover important signs and internal relations between the object and actions in a variety of situations that outline the overall activity (Lalov, 2003). This thesis can be supplemented by the fact that in absorption of signs of higher levels the speed of recognition and the reaction to external events is increased. Operation with summarized signs enhances the content of the operational information compensating for the relatively limited volume of operational memory.

We summarize the above as follows: the initial predictive mechanisms are evolutionary ; by filtration and selection of the valuable “information” they are constantly expanding (without any limit for perfection) at different levels; once they are built they start to act subconsciously; internal operation with structures (inherent only to man) is as much more successful, as the more complex the situations we can imagine are; our ability to “interpolate” develops in a restricted area by playing variants (outlining important signs of the problem solving process) and binding signs of the situation with the signs of the changes; the operation with summarized signs increases the speed of recognition.

The briefly presented theory of extrapolation of B. Lalov and the experimental and theoretical facts, which it is based upon, support our view that POS and the visual ideas in the process of problem solving are formed and used as a function of selection and development of a network of predictive mechanisms through which possible traits of the expected event are superimposed and the interpolation is realized as a principle of work of the natural human intellect.

It is easy to notice that the idea of forming of a fully-fledged system of predictive mechanisms to a great extent coincides with our understanding of the formation of operational-activity structure of the skill to solve problems, namely – highlighting important signs at different levels in the direction of integrity.

The most important peculiarities of the perception-operating schemes and visual ideas in cybernetic aspect that can be manifested in the ability to solve problems are:

- Visual ideas are sometimes very difficult to express in words;
- Visual ideas have no limit for improvement in a limited area/field;
- Visual ideas are hard to carry but have a high durability;
- A process of linking of methods and ideas to solve problems with visual ideas takes place and hence acquirement of sense.

The variety of methods for problem solving is immense. Attempts of systematization are found in [Milushev 2010].

In support of the above we present you the view of academician A. D. Aleksandrov (1912-1999) about the philosophy of teaching geometry in the mathematics school course. He is one of the most famous figures of the XX century in the field of geometry, the founder of the Aleksandrov's School of Geometry now known in the world as the "Russian Geometry". Winner of a number of international awards among which one of the most prestigious is the L. Euler medal, awarded to him in 1992. The reason for using this view is the fact that the curriculum content in the mathematics school course in our country (in its geometrical part) is in line with it and that the approaches to teaching it are subject of a long and extensive research.

In his article "About geometry" (Aleksandrov, 1980), which is essentially programmatic, he sets out the principles to be met in geometry course and its teaching in the secondary school. The basic idea is that geometry in its essence is a compound of the living imagination and the strict logic in which they mutually organize and guide each other. This is the peculiarity that separates it from the other parts of mathematics, as well as from other sciences. Therefore, geometry must be taught as a conjunction of the visuality and logic, as a living spatial imagination pierced by strict logic. And to the extent that geometry has emerged from practice and is applied in practice its teaching must reflect practice and be related to the other disciplines.

Since in exposing theoretical facts to pupils usually are offered ready results of imagination work (drawings, models and reflections that guide the imagination), the main activity for creating spatial images and operating them is solving problems.

Fundamental point of A. D. Aleksandov's view is that he characterizes geometry and its teaching as controversial. It is difficult to combine such properties as living imagination and strict thoughts. Living imagination is rather close to art and strict logic is a privilege of science. In teaching of geometry three closely related but also contradictory elements must be included: logic, visual concepts and real objects. He finishes his program article with the thought that the improvement of the school course in geometry and the realization of the profound task in terms of its universal meaning is in harmony of the visual and logical, achieving the maximum possible simplicity and clarity – all this is difficult enough.

Another essential point of A. D. Aleksanrov's view is that:

- The basic object of study is the geometric figures;
- The basic method when solving problems is the geometric one where the proof/evidence or the solution is guided by visual concepts.

It is best when the solution is apparent from a visual picture. It is very useful to attract visual considerations about: continuity, movement of points and figures, symmetry, solving triangles.

V. I. Ryzhik considers that the main problem is how, for many years but without significant interruptions and gradually, to develop the brain's capabilities that create the visual concept and operation with it (Rizhik, V. I., 1995). Of great importance is the creation of and operation with spatial images, since the facts of stereometry are displayed conditionally. For this purpose it is necessary to select and compile appropriate sets of problems.

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Do the presented above give us information for explanation and development of the A. D. Aleksandrov's view and to what extent through it can be enriched the prototype of the problem solving skill?

In a global aspect the following can be said:

The creation of visual images and the operation with them have an essential role in combining the geometric imagination with the logical thinking (i.e. when working out the ability to solve geometric problems) by visual presentation of the problem, seeing the solution and its logical conduct.

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