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Geometric Polyformisms As The Catalytic Factors That Activate And Dynamize Teaching Of Mathematics To Children With Special Needs

Djoko G. Marković* and Čedo L. Veljić

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Univesity of Montenegro, Faculty of Philosophy, Nikšić, Montenegro.

ABSTRACT

Interpretation of a phenomenon that can be presented as a geometric polyform enables a dynamic approach to the problem, resulting in an all-embracing and grasping and understanding of the given phenomenon. The objective of this work is to point out that the geometric polyformisms, as the fundamental factors of the polyform principle, that is to present them in a functional connection with the breaking the formalisms in everyday teaching of mathematics. Also, we advocate the opinion that geometric polyformisms rely upon the fact that pictorial thinking brings about 'aha' moments, thst is, sudden 'flashes' that enlightens in full the whole three-componentness of the studied phenomenon, which is especially important in the work with children with special needs.

Key words: Geometric polyformism, Polyform principle, Methodological innovations and Breaking formalisms.

*Corresponding author.E-mail: djokogm@hotmail.com.

INTRODUCTION

Traditional teaching is lacking the changes, diversification, individualization, and dynamism, and is reluctant to accept the facts that come out from modern socio-economic and scientific-technological development. It still represents an obstacle to the advancement of modern didactic and methodoligical ideas. Modern teaching of mathematics should induce and incorporate the mentioned elements and the modern classroom should be transformed from the classical lecture hall to a workshop of active, dynamic working process. Five centuries BC, great Chinese sage Confucius said that the best teaching method is the one which requires from the pupils perception of the subject by engaging all of their senses. The views that he accepted as axioms have been experimentally confirmed by modern psychology The ways of how students acquire teaching contents are best illustrated by the Dale cone (Figure 1) (Marjanovic, 1996, 2008). The teaching process should be based on the evdent psychological fact that the changes and diversity in the work are refresshing, while monotony mainly induces lowering of the interest and leads to passivity and boredom. If looked through the prism of "activity and dynamism" teaching relies greatly on a methodically important principle, the polyform principle a "motivating light" in teaching, especially of special needs children.

PLACE OF GEOMETRIC POLYFORMISMS IN THE TAXONOMY OF MATHEMATICS TEACHING METHODS

The diversity of geometric polyforms in combination with arithmetic, algebraic and methodological diverisity make the polyform principle which is based on a finite number of conjunctions of logical laws or principles (the law of

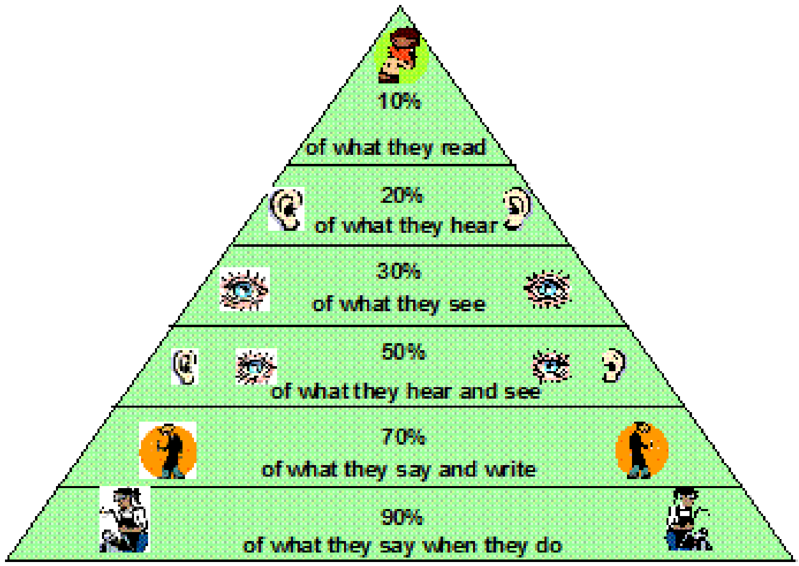

Figure 1. the Dale cone.

negation of negation, modus ponens, principle of evidence, principle of permanence, etc.). The essence of this important teaching principle consists in the constant insisting on an integral perception of the diverse, mainly geometric, approaches to the comprehension of the studied notions. In practice, this requires that the teacher possesses excellent professional knowledge and skills in the application of diverse didactic-methodological possibilities, to induce intense mental activity of the students, to get them involved in a motive-driven activity. When we speak of teaching contents we think of the selection of such problems that make possible the application of a number of diverse approaches in their solving using visual aids. However, the organization of such classes requires appropriate application of the polyformity of methodological forms and details, that is, their variation during one and same class.

The methodological forms and details, planned and applied by the teacher in the teaching process, are to be based on the timely "pulsation" of the didactic principles involved, that is, on their dialectic unity. To speak about any segment of modern mathematics teaching is not possible without relying on the achievements of modern educational psychology. Hence, it is surprising that the polyform principle has not received a due attention in the mathematics teaching methodology, although psychological theories underline its importance Marjanovic, (1996). Our overall knowledge of the outer world is acquired through our senses (sight, hearing, touch, smell and taste), of which sight is considered to be most precious. Namely, psychologists claim that more than two thirds of knowledge we acquire 'through eye-sight'. Eye sees objects that emit and reflect light. It simultaneously sees a great number of details, but our attention is focused only on some of them, and here ends the similarity of the functioning of eye and camera. Perception is not mere vision, and the selection of some details and their comprehension are inseparable from it.

Thus, perception is the process in which sense impressions are being interpreted and given a certain meaning. Therefore, the observation often involves the appearance of the background, when one object is in the forefront, and the rest is in the background. For example, in Figure 3 we can percieve two Maltese Crosses, either the empty or the shaded one, depending on which of them we focus our attention.

Tendenciju da „loše“ oblike prikazujemo kao „dobre“, predstavlja osnovni princip percepcije (Marjanovic,1996; 2008). The interpretation of what we see depends on how we relate a certain object to our inner image of them. Thus, the picture shown in Figure 2 we can percieve as a polyform as a hexagone, as a cube, and as a trihedron. All depends on the interpretation. If we percieve that the object is in the plane of the paper, it is a hexagone. If, however, the focus (central) point is in front of the paper, then the picture represents a cube (hexahedron). Finally, if we "push" the focus point behind the plane, then we see a trihedron. All mathematical notions are abstract and three-component entities, that is, a notion consists of three constituents (Marjanovic, 2008).

(1) Example (lowest degree of abstraction).

(2) Name (it is in the frame of the language system we speak supplemented by a mathematical symbol), and

3) Mental picture (inner notion, usually given in the form

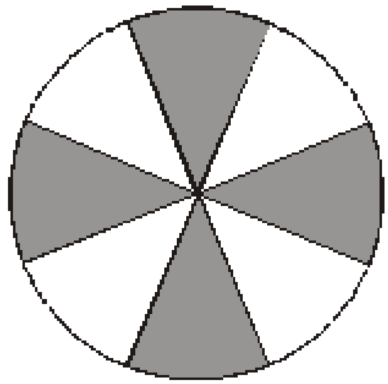

Figure 2. Maltese Crosses.

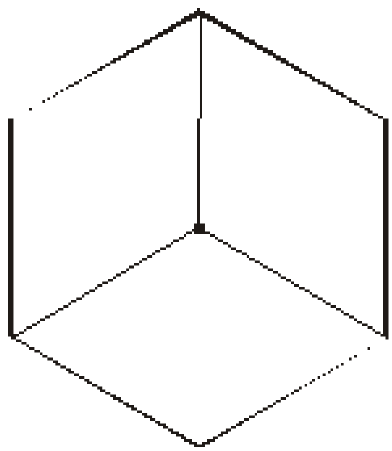

Figure 3. a polyform percieve.

of a simplified icon ideogram which is more persistent in our imagination than a particular impression). If we are not able to grasp any of the mentioned components of a notion, it remains bulurred and incomprehensible. In the process of knowledge acquisition best results are achieved if the knowledge is acquired through engagement of all our senses or of a majority of them. When verbal (monological and dialogical) methods are applied, the knowledge is acquired primarily through hearing. When the textual method is used, the knowledge is acquired through seeing. However, in the application of the combined verbal-visual and illustration-demonstration methods, the knowledge is acquired through all five senses, leading to the integral three-component picture of the given notion. Geometrical polyforms cannot be classified either as teaching methods or teaching forms, but, in the symbiosis with other polyforms they form the polyform principle.

The polyform feature of the effective perception along with the appropriate application of the combined action of several methods accelerates the process of assimilation and formation of notions by learners if compared to the knowledge acquisition by the verbal-textual method (Butler, 1960). Because of that modern teaching of mathematics should be based on the application of a combination of the verbal-textual, illustration-demonstration and the laboratory-experimental methods, by implementing them in the form of the polyform unity of of their teaching forms. In the beginning of the third decade of the twentieth century, Rudolf Arnheim, one of the founders of gestalt psychology, wrote his capital work he based all his statements on the geometrical interpretations (Leo, 1983; Arnheim,1985). Drawing is the first step to abstraction (the important properties are condensed and the unimportant ones are neglected). Geometrical figures are made to stabilize our inner notions. Visual thinking – thinking in images is characterized by comprehensiveness, and it is not easily transposable. Figures, that is, icons, represent the bearers of information. Because of that I.F. Sharygin says: "When we speak of 'good geometry' at the center of the story should be the problem presented by a beautiful figure and in a 'vivid language'". The 'vivid language' makes visual thinking to be easily transposable (Butler, 1960; Sharygin, 2004). The combined action of the verbal-textual and illustration-demonstration methods offers wide possibilities for the effective application of the polyform principle. This should be especially emphasized when we speak about its application in the form of the components of the teaching content, that is, of the geometrical polyformism.

The answer to the question 'Why it is so?, lies in the above facts, as well as in the fact that visual thinking has the property of comprehensiveness, that is, integrality, that brings about "aha" impressions which are catalyzed by the different presentation of the same example. In this way it is possible to present the given problem in a simplest manner, for example, in the form of pictograms, which facilitates the formation of the ideograms of mental images. The efficiency of the application of geometric polyformisms is based on the multiple usage of the principle of evidence intrpreted through iconic presentations. We should also metion here the evident psychological fact that the changes and diversity in the work contribute to the refreshment of the teaching process, while monotony induces the lowering of interest and appearance of passivity and boredom. It is easy to notice that in the methodology of mathematics teaching the polyform geometric interpretations cannot be classified as a methodical particularity, methdological form, or a teaching method. It is obvious that we deal here with something that is more important, that is, with the principle.

The polyform priciple is a notion that is wider than the geometric polyformism since, in addition to the geometric polyformism, it includes all non-geometric polyformisms. From the standpoint of mathematics if the didactic polyform principle is presented by the set A, and the phenomenon of geometric polyformisms by the set B, then $B \subset A$. It is clear that one can pose the following question: Is it possible to prove that we deal here with a principle? An elementary proof was given by the first author of this paper as follows:

If it is indisputable that the evidence (presented as trivial proofs by applying laws of logic) is a principle, and the permanence (preservation of formal laws) is also a principle, then every chain of conjuctions of a finite number of evident geometric or non-geometric proving activities or multiple conjuctions of permanences is also a tautology, that is, a principle, since $T \wedge T \wedge ... \wedge T \Leftrightarrow T$ (Markovic, 2008). Polyform geometric interpretations and other different proving activities are not methods but they represent principles. Because of that, active teaching, which is based on the polyform principle, cannot be identified as a method.

The theoretical proving of the generality of the polyform principle is at the same time a proof of our several-decades-long experience, which has power of at least of one or even more "modern" methdological experimets. There are not a small number of methodologists who classify activity as separate methods and thus "modernize" traditional understanding of the principle of conscious activity by naming it as a set of methods. However, the application of the didactic polyform principle, which always induces conscious activity, and does not deny the values of the traditional methodological-pedagogical-psychological thought, is the best answer to those "modern" interpreters of the notion of activity. Because of that this principle should have a general role that would be realized as ennobling of teaching with diverse contents, means, procedures and methods. Concerning the contents, we think of the selection of such problems whose solving will allow the application of diverse approaches and visal aids. However, the organization of such classes requires the appropriate application of diverse methodological forms and teaching particulars, that is their variation as well as of methodological innovations during a class.

One can speak of teaching methods and principles as separate things, but it is necessary to bear in mind that they never act independently of each other. A dialectic unity of the basic teaching principles and methods is an essential prerequisite for a well-planned and organized modern teaching. It is also necessary to point out the fruitlessness of the theorization of classical pedagogy, that is, the didactics of teaching principles, which are almost always considered in an isolated and simplified form. Such rigid static treatment of teaching principles is detrimental to the understanding of the teaching process, a consequence of which is the static attitude to teaching, which inevitably leads to formalism. As a result, the acquired contents of students' knowledges do not comply with modern knowledge taxonomies, for example, of the Marazan (Markovic, 2008) or some newer type.

THE IMPORTANCE OF GEOMETRIC ILLUSTRATION (PICTOGRAPHIC PRESENTATION) IN THE FORMATION OF ELEMENTARY METHEMATICAL NOTIONS

In the process of grasping the three-component feature of mathematical notions of great significance is the level of example and the possibility that the students percieve the studied phenomena by all their senses. Because of that they are to be shown different models which they can view and play with them, and then draw them, to present them in the form of pictograms, and thus arrive at the simplest level of their presentation in the form icons mental images. This, together with the "live" wording (naming) and symbolic interpretation makes the three-component character of the given abstract phenomenon (Marjanovic,1996). And this is especially important in the work with the children with special needs, bearing in mind

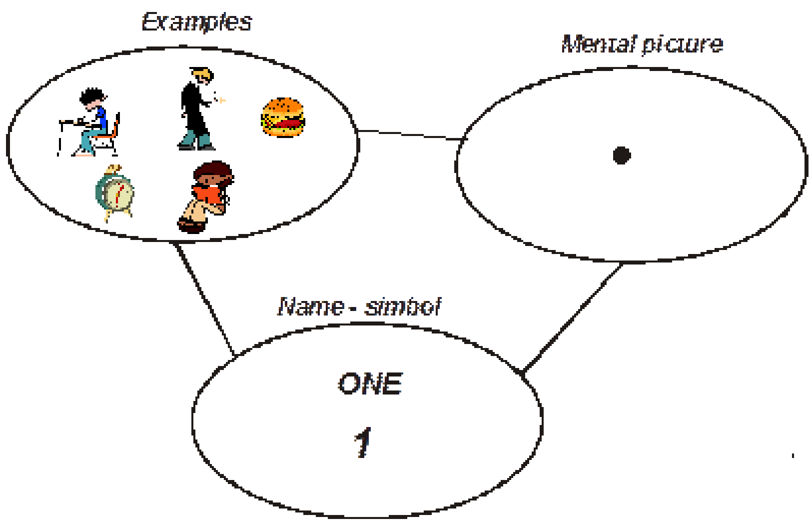

Figure 4. three-component entity.

that geometric figures are endowed by the property of integrality. They can say more than a multitude of words, and at the same time stabilize the corresponding internal notions, thus contributing significantly to the formation of the three-component feature of the given notion.

In the beginning of theaching of mathematics, special attention is paid to the formation of the notion of natural numbers and operations with them. Before the formation of the notion of natural number, the notion of more and less we associate the elements of one set to the elements of another set. The set approach to the formation of the notion of natural numbers is in fact based on those elementary set notions association of the elements of one set to the elements of another set, comparison of the sets, and formation of the notions of "equinumerousness" and "non-equinumerousness". In this compaeison use is made of the "1-1" (one-hyphen-one) association and counting of the elements. By comparing the numbers of the set elements students can conclude that they are "equinumerous" (equivalent) or "non-equinumerous" (non-equivalent). In view of the fact that equinumerousness is a relation of equivalence, for each class of equivalnce we choose its represntants numbers, and the students compose, percieve and select new examples of the sets that belong to the same class number or to some other class,that is, to some other number. Thus, by comparing the elements from the same class, the students perform first physical counting and association, using the didactic material that was prepared in advance, followed by graphical presentation and, finally, comes mental correspondence. The application of Venn diagrams leads to a higher degree of abstraction. The Venn diagrams abstract the essential and neglect the irrelevant (noise). The relation of "equinumerousness" of the sets, as a relation of equvalence breaks the sets into equivalence classes, which are represented by numbers.

By presenting a larger number of the corresponding models, along with the students' sketching them as pictograms and then as ideograms, enlightened by "live wording", the number appears as a three-component entity, at the same time in the form of example, mental image (trivial ideogram) and the name symbol. For example, for the number 1 we take a series of concrete examples (one boy, one girl, one teacher, one desk, one chair, one clock, one pencil, one book, one sandwich, etc., and we use the symbol 1 word "one") (Figure 4). The mental image of the number "one" can seen as a dot on a domino piece. In this way the students form a clear integral three-component image of the notion of the number "one" by the simultaneous perception at the level of example, at the level of mental picture, and at the level of symbol (word).

Such interpretation of abstract notions by geometric polyformisms relies upon the fact that "thinking in images" leads to "aha" moments, instantaneous flashes which illuminate in full the three-component nature of the problem that is being taught. This gives excellent results in the acquisition of knowledge, that is, in its persistence and application, which is of great importance in teaching, especially when dealing with so sensitive population such as are children with special needs (Markovic, 2008). Therefore, the very diversity of demonstrations by models or dynamic Power Point presentation (for example, in the polyform presentation of the equivalence of the areas in proving the Pythagorean Theorem, and the like) and the imaginative perception of elementary mathematical notions represent catalytic factors in the work with children with different disturbances in their development (Markovic, 2008).

At the same time, this has a stimulative effect on the development of their cognitive and motoric abilities.

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