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The Use of Sign and Symbolic Visual Aids in Biology Teaching under the Conditions of Schools Shift to the Federal State Standards of the Second Generation

Nelya Z. Smirnova^a and Ivan A. Zorkov^{b*}

*^aKrasnoyarsk State Pedagogical University
them. VP Astafeva*

89 Ada Lebedeva Str., Krasnoyarsk, 660049 Russia

^bCenter of Education № 1

34 Maerchaka Str., Krasnoyarsk, 660075 Russia

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Didactic peculiarities of sign and symbolic aids are reviewed in the article; some of their aspects applied to biology teaching are analyzed, basic principles of sign and symbolic aids projecting under the conditions of schools shift to the Federal State Standards of the second generation are described, examples of modern sign and symbolic visual aids used at biology lessons are given. Efficiency of created sign and symbolic system is proved by the authors, applying of it promotes students' knowledge in biology improvement, memory refinement, and growth of the level of biological notions adoption.

Keywords: biology teaching, visual aid teaching, sign and symbolic methods, systematic and action approach, cluster, frame and algorithm.

Knowledge functionalization and actualization, prevailing of action approach, humanization and humanitarization of educational process designed in new educational standards and exemplary biology curricula changed the functions of sign visual aids and the character of its use in education. In its turn, that led to many psychologists and methodists' attempt to criticize general didactic principle of visual aid thereby to rethink such element of the system of educational process as sign aids of teaching.

Objectives put before secondary school by the society, new educational concept and search for effective didactic methods make looking at the problem of visual methods aids of education in another way, changing the strategies of their use. At this stage of development of the domestic school education of an action, independent and competent personality with scientific-humanistic and eco-cultural world outlook has become the main goal of general education (Smirnova, 2004; Kozulina, 2012; Smirnova et al., 2010). "The main component of modern scientific knowledge

adoption is mastering of the method of sign and symbolic aids use” – notes B.Ts. Badmaev (Badmaev, 2002). These aids are structural elements of educational and methodical complexes, information put in the Internet and electronic educational aids that’s why the key moment in modern natural-science education is following the demands to the sign and symbolic aids development and methodology of their use at a lesson. In the theory and methodology of biology teaching the problem of sign and symbolic visual aid as an efficient way of the level of biological notions adoption growth was researched earlier by such scientists as D.I. Traytak, A.V. Temerov, I.A. Mezentsev, A.M. Rosenstein, L.V. Rebrova, N.M. Verzilin, I.N. Ponomaryov and B.A. Pistnikova (Traïtak, 1977; Temerov, 2000, 1987, 2001a, 2001b; Mezentseva, 2006; Rosenstein et al., 1989; Rebrova et al., 1997; Verzilin et al., 1938; Ponomaryova, 2003; Postnikova, 1991).

Analysis of psychological and pedagogical literature devoted to the problem of sign visual aid in biology teaching showed definite lack of scientific and methodical information about this problem thus that subject was chosen for the research. The choice of the subject is also stipulated by the results of the Krasnoyarsk teachers’ poll, 70 % of them have vague understanding of principles of development and applying of modern sign and symbolic aids. In the majority of scientific articles and monographs the option that sign and symbolic visual aid as the sum-total of visual aids of teaching replacing specific subjects revealing under certain structure inner connections and essence of the subjects, phenomena and processes is supported by the authors (Petrov, 2007; Gostar, 2008; Sapogova, 1993; Sverchkova, 2009; Smolnikov, 2004; Tatzhiev, 1970; Fridman, 1984). We think a more precise definition is given by A.V. Temerov, he defines the sign and symbolic visual aid as visual

method reflecting the structure and the function of the replacement and encoding process modeling look based abstract dependences and concrete peculiarities through conditionally symbolic form (Temerov, 2000).

Being a methodological base for new Federal State Educational Standard (FSSES), systematic and action approach supposes that students have the ability to orient fast in training situations arising at the lessons. Classical sign aids, for example, the schemes of activity – reference bases for actions (RBA) and reference schemes for activity implementation (RSAI) do not provide with desirable effect when using them as they often confuse a student by their elements of the same type and complex connections between the components when solving biological problems and they hardly help develop algorithmic thinking. These are noticed both by domestic and foreign researchers (Anastasova, 1970; Mokriy, 2012; Martin et al., 1989; Muhanova, 2012; Deporter et al., 1998; Laudan, 1987; Fakushkina, 2009). According to change of social formation from industrial to informational growing volume of educational information demand applying new sign aids with the help of which biological content must be adopted more intensive by the students, that can hardly be done at the use of component-schemes and graphs of educational information developed in the methodology of biology teaching under knowledge approach and classical model of teaching (Lavrentyev, 2002; Botvinnikov, 1979; Veraksa, 2006). Alternative to table visual aid have to be found as well to increase the sign aids function to development of logical thinking and metasubject universal educational actions that mean students’ ability to structure educational information by means of sign and symbolic activity.

In modern educational standards of the second generation mastering of basic subject,

metasubject and personal competences or results of education by the students are supposed to be the final result. Subject results of the school discipline "Biology" are reached by methodical use of different technologies, methods and aids of education (Smirnova, 2012a).

Sign and symbolic visual aid as one of the didactic aids encode and schematize the content of basic biological notions, mastering of which is supposed by minimal adoption of school biology content. According to mentioned above it can be stated that activity with sign and symbolic aids provide with reaching subject results by the students, adoption of biological notions in the process of their visualization, encoding and decoding by the students. Special role of sign and symbolic visual aid should be mentioned while mastering of metasubject results of education by the students (Veselov, 1999; Zorkov, 2012).

Ability to process and interpret educational information, emphasize the most important, work with the text that are metasubject in their character are formed and develop quite well when working with sign and symbolic aids. For instance, making memory cards for some biological course theme provides with development of students' ability to visualize educational information, emphasize the most important, systemize and find interconnections and therefore formation of general scientific competences.

For the last tens of years demands to sign and symbolic aids in natural-scientific education have changed greatly. In biology teaching the role of clusters, frames, algorithms and picture-ideographic writing as an alternative to classical schemes, tables and pictures is becoming more important. According to Z.A. Skripko, modern aids of sign and symbolic visual aids must be characterized by such qualities as isomorphism and simplicity, easiness in understanding and students' activity when working with them, playing the role of outer support for students'

inner actions, underlining of essential in the sense of perception (Skripko et al, 2007).

Speaking about biology teaching L.V. Rebrova gives the following principles that a teacher should be guided when developing sign and symbolic aids: visual method, laconism, structural properties and asymmetric property of component cells, diversity of signs and symbols, graphical and colour differentiation, practical orientation, variety of speech formations and mnemonic abbreviations, mobility, use of usual associations, economy and memorability (Rebrova et al, 1997). Following Z.A. Skripko and L.V. Rebrova we take the view that aids of sign and symbol visual method (SSVM) under conditions of schools' shift to the FSES of the second generation must have the following characteristics.

1. SSVM must contain signs and symbols coordinating only essential educational information.
2. SSVM must have maximum conventionality and use usual for students associations and conceptual contexts.
3. SSVM must have minimalism and artistic simplicity not causing any students' difficulties with its representation as well.
4. SSVM must have structuring and succession of elements. Signs and symbols must be connected semantically (according to their sense).
5. SSVM must be laid down from universal and easily grouped signs and symbols that students could use in different training situations giving them diverse contexts for education intensification.
6. SSVM must have comfortably perceived diostage (the scale of sign and symbol aids if they are created by the students must not be less than the format A4 and more than A3).

In the course of four-year research of sign and symbol aids efficiency we formulated certain methodical conditions for the sign and symbol visual aid use by the example of educational field "Biology". We shall enumerate some of them:

- when working with sign and symbol aids it is necessary to choose the best combination of simultaneous and successive perception, central and peripheral vision;
- perception of sign and symbolic aids must be organized parallel to perception of a natural visual aid that they denote (it is especially important when demonstrating new for students sign and symbolic aids);
- for the primary perception on the stage of a new theme studying the students are suggested in turn or in pairs consideration of the elements of sign aid synchronously with a teacher's speech (stage must not be demonstrated at once);
- students must be able to make activities of encoding, decoding, schematization and modeling that's why it is necessary to organize students' unassisted work with sign and symbolic aid, to work out tasks on frames, clusters and algorithms making to the paragraph.

The given list of methodical conditions is not constant; it needs permanent updating and checking. The majority of Krasnoyarsk school teachers using sign and symbolic aids at their lessons are guided by demands similar to mentioned above. This fact brought out in the course of biology teachers' poll proves the efficiency of the discussed methodology but some of mentioned above demands are not always taken into account by teachers, it shows the necessity to continue researches in the frames of the problem of the use of sign and symbolic visual aid in biology teaching. Further we should give some examples of sign and symbolic aids included

into our developed system of signs and symbols visual aid, efficiency of which was proved by the pedagogical experiment at biology lessons in grade 9 of a secondary school.

In connection with frame approach penetration into the methodology of education frame models are becoming an alternative to classical graphic visual aid at biology lessons more often. Supporting summaries by V.F. Shatalov widely used in education lately are replaced by frames that have come to the domestic school from foreign pedagogics.

Frame model is an updated form of educational information recording by supporting signals and presents abstract image of standard stereotype situations in symbols – peculiar rigid construction (framework) containing empty windows as elements – slots that are reloaded by information many times unlike supporting summaries and classical table visual aids that are static pictures including visual and verbal text of a certain paragraph (Fig. 1) (Anikeeva, 1992; Rosenstein, 1989). Consequently "...if students can symbolically depict a studied object it means they have notion of it clear enough. No doubt it raises the degree of perception and mastering of the material" (Badmaev, 2002).

"Use of frames in visual aid of education allows building interaction by the scheme "teacher – text – student" that corresponds to modern approaches to education stated in State Educational Standards of the second generation; function of a teacher changes to the direction of coordinator or facilitator and function of a student gains the character of inner dialogue with the author or the source of educational information" (Lavrentyev, 2002). As an example of educational frame in biology we present the problem frame that reflects the situation of solving the problem of natural resources reduction (Fig. 2). The given frame is a stereotype construction allowing constant change of slots with text content and

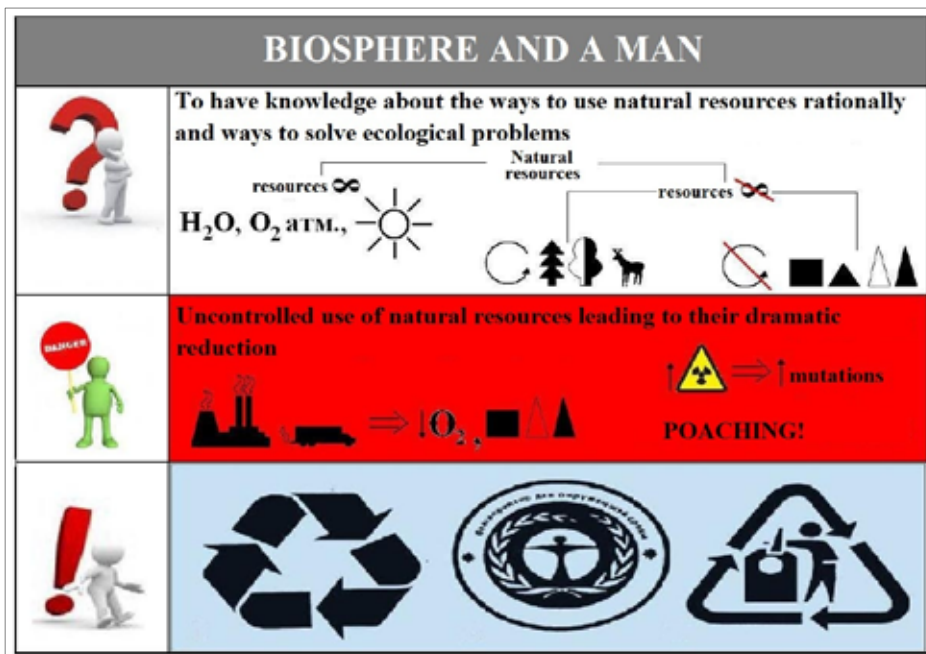


Fig. 1. Problem frame “Biosphere and a man”

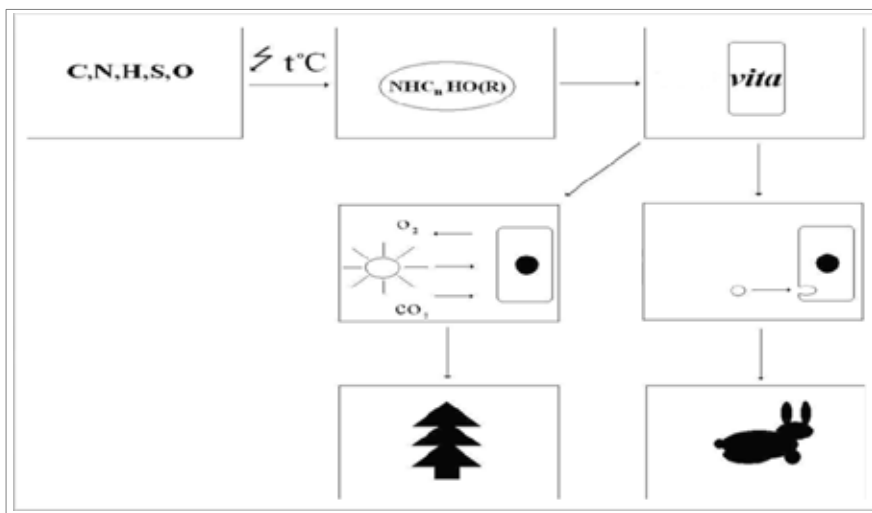


Fig. 2. Algorithm “Life origin and development on the Earth”

it promotes structuring of any information in problem education.

In connection with action approach prevailing in biology education that is demanded by the new educational concept along with frame systems in school biology visual algorithmic

languages are used. These visual aids are the chain of components of practical and mental activity fulfilled at this stage of education (Smirnova, 2012b).

In the judgment of methodists-biologists researching the problem of algorithms applying

(Skripko, 2007; Grinkevich, 1962; Urban, 2008; Chobotar et al, 1987), these aids replace classical word-image visual aid that is less effective for forming biological notions with students.

Visual algorithms promote students' realization of connections of theoretical constructions with practice, provide with succession and logics of a content statement of a subject without losing the main principle from the whole mass of studied information (Lebedev, 2010; Salmina, 1988).

In Fig. 2 algorithmic structure used when studying paragraph 14 "Modern view on life origin" and paragraph 15 "Primary stages of life development" of the textbook by S.G. Mamontov "Biology. General laws. Grade 9" is presented (Mamontov, 2006).

Except for frames and algorithms in modern natural-science education cluster models that changed classical component-schemes gained wide use. Clusters play the same role as component-schemes – structuring of educational information, emphasizing key notions, depicting the structure of the educational information. Firstly this kind of sign and symbolic visual aid was used at American schools when studying foreign languages. In 90s of the last century

clusters were used in biology teaching at domestic schools. Clusters are set of key notions that are recorded as hierarchical branching bunch or terminological nest (star clusters) (Lavrentyev, 2002; Panov, 1980).

When developing a cluster in the middle of the first line a word is written that reflects the theme of the study in general, there are notions already known to the students and found in the textbooks by them associated with the subject of the study reflecting some features, principles of actions, quality characteristics and descendant phenomena in the second line. The number of such words can be different and every word will be a branch of a word of the first line. Desirable condition: every bunch must contain words with close sense meaning or the same classified feature (Bowen, 1971; Suvorova, 2010; Tuganbaev et al, 2003; Mihelkevich, 1998). Cluster of a star type used when study paragraph 21 "Inorganic substances included into cell content" from the textbook by S.G. Mamontov "Biology. General laws. Grade 9" is shown in Fig. 3.

By example of new material explanation on the topic "Natural resources and their use" from the textbook by S.G. Mamontov "Biology. General laws. Grade 9" (Mamontov, 2006) we'll

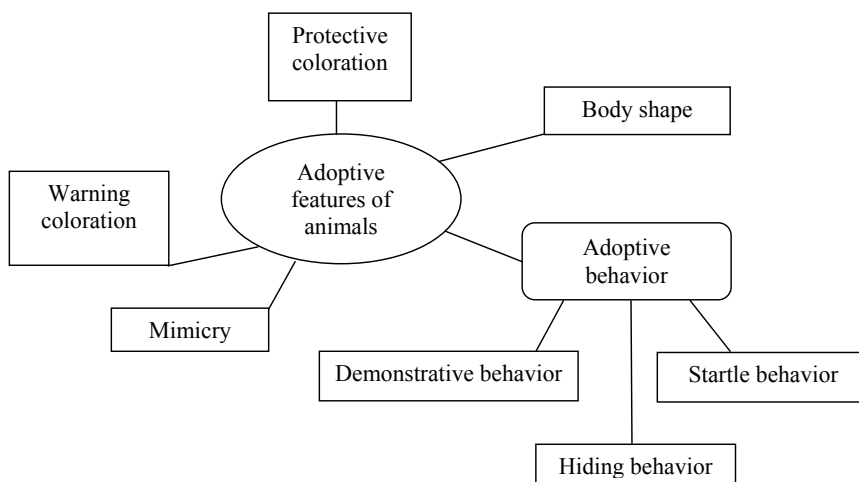


Fig. 3. Star cluster "Adoptive features of animals"

reveal the methodology of sign and symbolic visual aid applying in biology teaching. The new material rendering is conditionally divided into 3-4 graduated stages with obligatory statement of tasks and ways of their solvation.

Stage one

Aim: Meeting with types of natural resources and peculiarities of their use.

Pedagogical goals:

- improvement of memory and attention with the help of activity with aids of sign and symbolic visual aid;
- development of logical thinking through ability to apply derived SSVMs in familiar (stereotype) situation;
- vocabulary and visual literacy enrichment with the help of inter-education in the course of primary understanding checking and material consolidation.

The lesson begins with the teacher's new material rendering, retelling about basic types of natural resources, about their classification on the basis of criterion of renewability and nonrenewability. Parallel to her/his retelling the teacher draws the first slot of the problem frame on the board (Fig. 1), where the information is represented in sign and symbolic form. In the course of such activity it is desirable to depict only 50 % of lesson material on the board, the remaining part of the frame is drawn later together with the students in the course of the rendered material understanding checking. The given feature of the methodology provides with the possibility for realization of the psychological effect B. Zeygarnik or the effect of unfinished action allowing improving the quality of material adoption considerably. Along with the aids of sign and symbolic visual method classical graphic visual method (pictures of the places of natural resources extraction) is demonstrated thus the correction of wrong notions and the work on visual images are exercised.

Stage two

Aim: To study the problem of uncontrolled use of natural resources.

Pedagogical goal:

- abstract thinking, attention and memory improvement in the course of following depiction of the problem frame.

The second stage starts when results of real knowledge satisfy not only the teacher but also the students. At this stage together with the class audience the second slot frame is completed (Fig. 2). The further rendering of the class material is connected with the previous one with the help of problem situation. Besides sign and symbolic aid natural aid (collection of petroleum refining products, natural fossils and so on) is used. The description of developing process of the problem situation is given below.

Until recently mankind hasn't thought about rational use of natural resources. From the Earth interior a huge amount of oil and gas has been taken and their combustion products have been discharged into the atmosphere in the amount of thousands of tones. In the middle of the XX century the scientists established a shocking statistics: under modern volume of extraction the last oil will be pumped out in 50 years and mineral carbon will finish in 200 years.

After the problem situation creation, discussion of rational use of natural resources the students are suggested completing the second frame slot (Fig. 1) that visually reflects the problem having stated by the teacher. Thus the primary knowledge consolidation is made at this stage.

Stage three

Aim: To develop possible ways to solve the problem of natural resources rational use.

Pedagogical goals:

- improvement of attention and abstract thinking in the course of unassisted making the final frame slot.

The students read the corresponding material in the textbook after that the discussion of possible ways to solve ecological problems begins. The stage ends by completing the third frame slot where the information of problem solvation having arisen at the lesson is encoded. Completing the final slot is made unassisted. After the work completion the variant of the third slot having made by the teacher is demonstrated to the class audience.

Consolidation of the studied at the lesson

At this stage the frame is completed, it allows the students combining all the information received at the lesson. With the help of finished frame generalization, correction and systematization of the knowledge is made, the conclusions are formulated. At the beginning of the next lesson the frame is demonstrated again. Thus repeated consolidation and revision of studied material are made.

During 2010-2012 we were conducting experimental work to study the problem of quality of students' knowledge improvement in biology in grade 9 when using sign and symbol visual aid in educational process. The participants of the experimental activity were teachers and students of secondary schools in Krasnoyarsk and Divnogorsk. Methodology of quality of students' knowledge improvement was developed in the frames of semiotic approach to biology teaching. Created sign and symbolic system was approbated and realized successfully as a result of proper pedagogical activity and got the positive resonance among pedagogical society of Krasnoyarsk and Divnogorsk.

A forming stage of experimental work included development of system of sign and symbolic aids, search for methodical recommendations how to use sign and symbolic visual aid that are mentioned in psychological and pedagogical literature, creation of original thematic planning being developed according to educational process peculiarities with the use of sign and symbolic visual aid. Planning of lessons content taking into account semiotic approach allowed using educational potential of developed sign and symbolic system in biology teaching, using huge specter of sign and symbolic means including innovative like frames, clusters, codes, algorithms, pictographs and ideographs, making activity of replacement, encoding and schematization when working with them at the forming stage of experimental work.

The results of the tests held at the controlling stage of experimental work showed positive results when compared to data received at former stages of the research. In whole the use of sign and symbolic visual aid allowed having 20 % improvement of quality of students of the 9th grade knowledge that proves hypothetical efficiency of developed sign and symbolic system of biology teaching. Graphical data of experimental work are shown in Fig. 4.

Thus, the researches prove supposed hypothesis of sign and symbolic visual aid efficiency in biology teaching. If follow given below methodic recommendations one can get really high rates of quality level of students' knowledge, intensify educational process, develop logical thinking and associative memory of students.

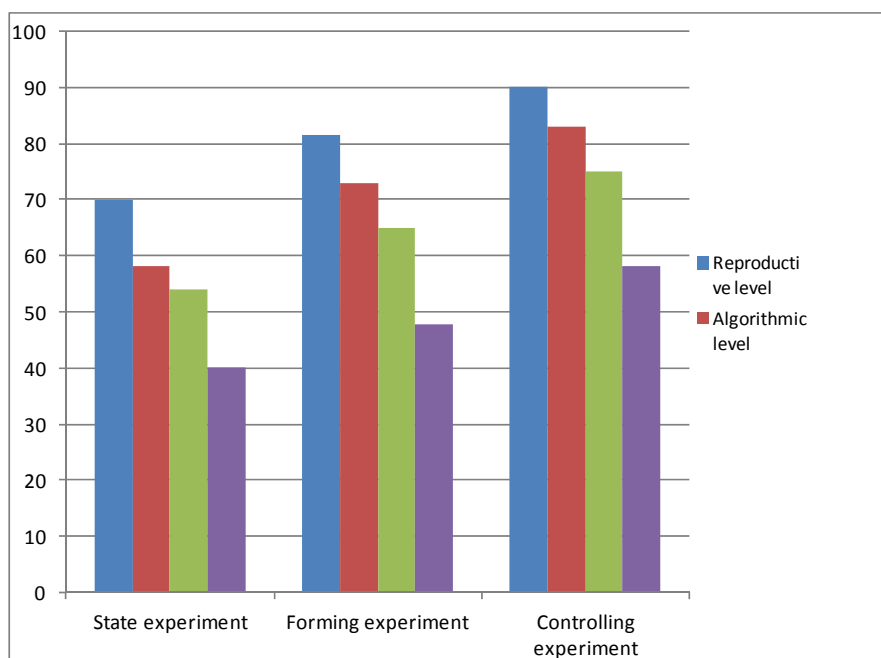


Fig. 4. The results of experimental work

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Использование средств знаково-символической наглядности при обучении биологии в условиях перехода школ к Федеральным государственным стандартам второго поколения

Н.З. Смирнова^а, И.А. Зорков^б

*^аКрасноярский государственный педагогический университет
им. В.П. Астафьева*

Россия 660049, Красноярск, ул. Ады Лебедевой, 89

^бМБОУ «Центр образования № 1».

Россия 660075, Красноярск, ул. Маерчака, 34

В статье рассмотрены дидактические особенности знаково-символических средств, проанализированы некоторые их аспекты применительно к обучению биологии, приведены основные принципы проектирования знаково-символических средств в условиях перехода школы к Федеральным государственным стандартам второго поколения, даны примеры современной знаково-символической наглядности, используемой на уроках биологии. Авторами доказана эффективность созданной ими знаково-символической системы, применение которой способствует повышению качества знаний учащихся по биологии, улучшению памяти, увеличению уровня усвоения биологических понятий.

Ключевые слова: обучение биологии, наглядное обучение, знаково-символические средства, системно-деятельностный подход, кластер, фрейм, алгоритм.
