E-learning

Vol. 12

Innovative Educational Technologies, Tools and Methods for E-learning

University of Silesia in Katowice
Faculty of Arts and Sciences
of Education in Cieszyn

E-learning

Vol. 12

Innovative Educational Technologies, Tools and Methods for E-learning

Monograph

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USE OF SPECIALIZED SOFTWARE FOR THE DEVELOPMENT OF VISUAL THINKING OF STUDENTS AND PUPILS

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Abstract: *The article reveals the essence and defining characteristics of visual thinking: visual productivity and activity of putting forward visual hypotheses, constructive activity, strategic-semantic flexibility, and visual originality. The ways of using specialized software for the development of visual thinking are revealed: the organization of visual search through the tasks visualized in the virtual environment, the use of tasks aimed at the developing the ability to put forward visual hypotheses, the use of tasks aimed at identifying visual originality in solving them, the use of cognitive-visual graphics, the use of tasks with incomplete conditions and tasks with redundant data, and the use of inverse tasks. According to the results of the expert assessment, two most effective ways in which to influence the development of visual thinking have been identified: the organization of visual search through the tasks of visualized in the virtual environment and the use of cognitive-visual graphics. It is established that for the implementation of these ways it is advisable to use specialized software, namely programs of dynamic mathematics, Smart-objects from the package of office programs, tools for creating infographics, and graphic editors. The results of a pedagogical experiment on the development of visual thinking of young people through visualized tasks in a virtual environment and the use of cognitive-visual graphics are presented.*

Keywords: visual thinking; specialized software; e-learning; programs of dynamic mathematics.

INTRODUCTION

Modern education faces some challenges. Among them are active and constant use of information devices (smartphones, tablets, netbooks) by young people; they need to be online all the time and perceive information content more visually than linearly and others. At the same time, educational material in educational institutions, due to the peculiarities of its presentation in textbooks (mostly in the text form), is usually not interesting enough to hold attention for a long time and effectively influence the development of the younger generation thinking. This highlights the problem of strengthening the cognitive activity of young people by changing the ways of presenting the material in terms of its visualization in order to develop visual thinking as a basis for the creativity of young people. And if the shift of emphasis toward visualization is traced today, the problem of the development of visual thinking and the means of doing it are insufficiently studied.

1. ANALYSIS OF CURRENT RESEARCH

The works of Arnheim, Ware, Moeller, and others are devoted to the study of the peculiarities of visual thinking (Arnheim, 1994; Ware, 2004; Moeller, 2013). Thus, scientists have substantiated: cognitive-visual methods of teaching mathematics, in a basis of which accents are shifted from illustrative function of clarity to its cognitive function, which has a positive influence on the development of visual thinking of pupils (Dalinger, 2006); the possibility of forming the skills of visual search activities in mathematics lessons through visual thinking (Reznik, 1997); psychological features of visual thinking, in particular, perception and reflection of connections and relations of objective reality through various forms of visual coding, namely models, graphics, schemes, maps, etc. (Symonenko, 2005). Certain theoretical and methodological principles of the development of visual thinking by using digital technologies are presented in the works of Andersoninman, Horney; Abdullah, Halim, Zakaria; MonesHattal, Mandes and others (Andersoninman, Horney, 1996; Abdullah, Halim, Zakaria, 2014; MonesHattal, Mandes, 1995).

At the same time, the analysis of scientific research shows the fragmentary nature of the work on clarifying the ways in which to develop visual thinking through the use of specialized software.

The aim of the study is to identify ways of using specialized software to develop the visual thinking of students and pupils.

The aim led to the need to do the following: 1) clarify the essence of the phenomenon of “visual thinking”; 2) describe possible ways to use specialized software for the development of visual thinking; and 3) based on statistical analysis, determine the most effective ways to use specialized software for the development of visual thinking.

2. MATERIALS AND METHODS

2.1. Research base

The study was conducted based on Sumy State Pedagogical University named after A.S. Makarenko. The pedagogical experiment was attended by 104 students of 3–4 courses of specialties "014 Secondary Education" (specializations – mathematics, computer science) and high school pupils of the Kyiv, Donetsk, and Sumy regions, with a total of 98 people.

2.2. Stages of research

The study took place in four stages: the first stage is theoretical, aimed to clarify the concept of visual thinking, its components, and its characteristics. The second stage is practical, provided for the identification of possible ways to use specialized software to develop visual thinking of young people. In the third stage, an expert assessment of the identified ways was carried out to select the most effective ones using the Kendall concordance criterion. The fourth stage involved a pedagogical experiment: during 5 sessions, two of the most effective ways to use specialized software to develop visual thinking selected by experts were proposed. At the beginning and end of the fourth stage, by means of the method of "Raven's Progressive Matrices" (Raven's test), the dynamics of the development of visual thinking of your people were determined and tested statistically by the comparison of students' mean scores.

3. MAIN RESULTS

3.1. The essence and defining characteristics of visual thinking

Dalinger explains the term "visual thinking" as thinking which is oriented on the reproduction of concrete, but previously unknown images, and which is relevant to the field of object transformation methods. When mastering mathematical content, the specificity of visual thinking lies in the activity of creating mathematical images, filling them with semantic load, operating on them, etc. (Dalinger, 2006).

Symonenko identifies the following visual-mental operations: "visual comparison; ability to visually differentiate and integrate structural elements; ability to highlight significant elements of visual structure; establishing of visual analogies; visual regrouping; visual synthesis; visual analysis; the ability to generalize "the vision" of the entire transformed structure at once – a visual generalization; visual abstraction" (Symonenko, 2005).

The *operational mechanism of visual thinking* includes the ability to visually differentiate the elements of the structure, the establishment of visual analogies, visual synthesis, visual analysis, the ability to generalize the "vision" of the entire transformed structure.

This gives reason to talk about the importance of mastering visual-mental operations, that develop visual thinking.

3.2. Ways to use specialized software for the development of visual thinking

To determine the ways in which to use specialized software for the development of visual thinking of young people we took into account the opinion of O. Ivanyuta, who states that "one of the defining characteristics of developed visual thinking is the ability to create new images and operate them, which is realized in the production of visual hypothesis, based on given stimulus material. The solution to the problem in images is carried out mainly based on visual material" (Ivanyuta, 2003). Therefore, below we will focus on possible ways in which to use specialized software for the development of visual thinking.

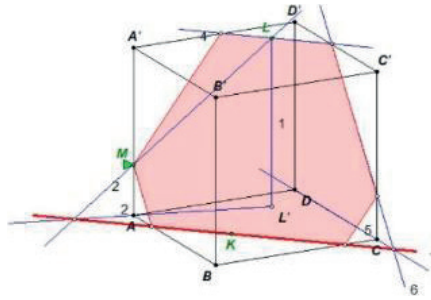
3.2.1. Organization of visual search through tasks visualized in a virtual environment

By the visualized problem we mean a problem "in which the image is explicitly or implicitly involved in the condition/answer, sets the method of solving the problem, creates resistance to each stage of solving the problem or explicitly, or implicitly accompanies at certain stages of its solution" (Knyazeva, 2003).

The use of visualized tasks allows us to quickly learn certain fragments of the theory, to formulate and disseminate a generalized algorithm of practical actions, to focus on the key points of the problem-solving process. Note that visualized problems are a tool for implementing a cognitive-visual approach to teaching mathematics and are a means of developing visual search skills.

The use of visualized tasks and mastery of visual search affects, in particular, at the development of strategic and semantic flexibility of visual thinking.

For example, when constructing sections of polyhedral passing through given points, in the program *The Geometer's SketchPad* it is possible to construct a section and to investigate the form of a section depending on an arrangement of the setpoints and conditions under which the section, in general, cannot be constructed (Figure 1).



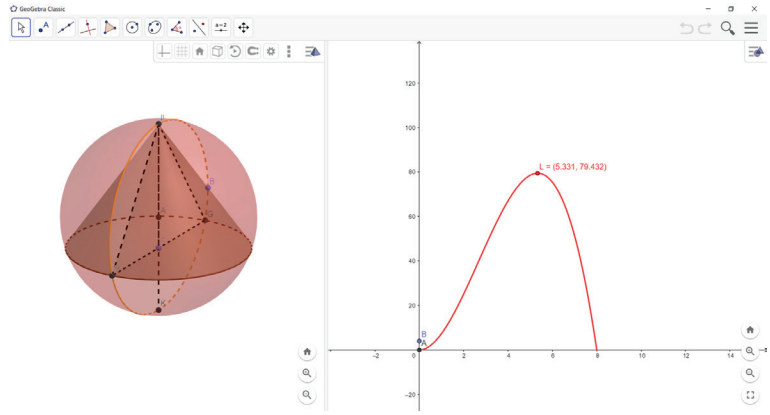
F i g u r e 1. Building a section of a cube in the program The Geometer's SketchPad (the section is a hexagon)

S o u r c e: http://aleshko.ucoz.kz/load/interaktivnye_stereochertezhi_v_srede_quotzhivaja_matematikaquot/24-1-2.

Programs of dynamic mathematics are suitable for organizing a visual search. This is emphasized by the authors of the article Semenikhnina (Semenikhina, 2019) and Proshkin (Astafieva, Bodnenko, Proshkin, 2019).

3.2.2. The use of tasks aimed at developing the ability to make a visual hypothesis

Visual productivity or the activity of making visual hypotheses is associated with the search for new methods of solving problems. For example, the use of a constructive method for solving geometric problems to the extremum (Figure 2).

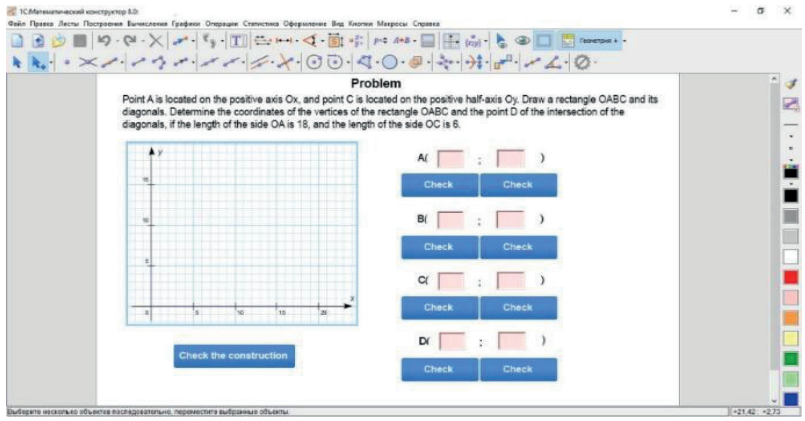


F i g u r e 2. A constructive method for solving geometric problems to the extremum

S o u r c e: Own work.

3.2.3. The use of tasks aimed at identifying visual originality in their solution

Visual originality is shown, in particular, at the use of non-standard computer tools at the solving of problems (for example, use of parametric color at the solving of a problem on GMT), in non-standard applications of computer visualization in the educational process (for example, as a means of visualized control of knowledge, shown in Figure 3), as a means of visual repetition of theoretical material, as visualized tips for solving problems).



F i g u r e 3. Tasks for visualized control of knowledge

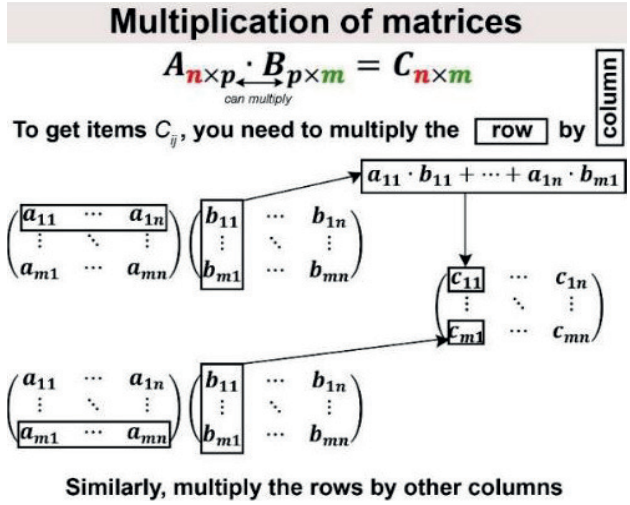
S o u r c e: Own work.

3.2.4. The use of cognitive-visual graphics

Educational visualization is used not only for illustration but also as an independent source of knowledge. Therefore, it is often realized through infographics – cognitive-visual models of presentation of educational material in the form of images, that "explain". The infographic is based on the theory of the "consolidation" of educational information (Klepko, 1998).

The use of cognitive-visual graphics affects the development of the constructive activity of visual thinking, resulting in the formation of skills of the selection of educational content, skills of processing, integration, and generation of educational information with a demonstration of deep connections between objects; the ability to systematize and analyze information; the ability to present a compact material with a focus on key information; visual translation skills; and programming skills.

An example of cognitive-visual graphics is given in Figure 4. The creation of such models is possible in a package of office programs (Smart-objective), in programs for the construction of smart card (X-Mind, Free-Mind, Mind-Meister, Spiderscribe, Mindomo, Mindmap, etc), graphic editors (Adobe Photoshop, Paint.NET, Photoscape, Photo Instrument, Movavi Photo Editor, The GIMP, etc).



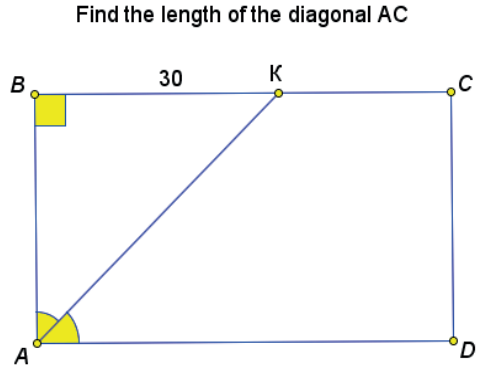
F i g u r e 4. Cognitive-visual graphics "Matrix Multiplication"

S o u r c e: Own work.

3.2.5. Use of tasks with incomplete conditions and tasks with redundant data

In problems with incomplete conditions (Figure 5) some data are missing, so it is impossible to give an accurate answer to the problem (Krutetskyi, 1968). But if you enter the required data, the exact answer can be found. When solving this type of task, you need to "grab" the formal structure of the problem condition and identify incomplete data. Additional quantitative or qualitative characteristics, that are irrelevant, incorrect, or that in some ways mask the data needed to solve are presented in problems with redundant data (Figure 6). When solving, it is necessary to select from the set of given

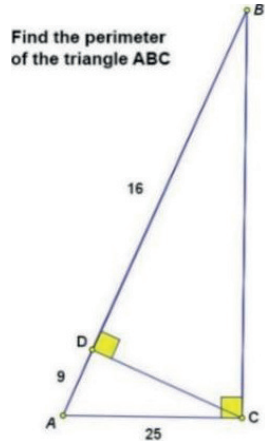
quantities exactly those that constitute the essence of the problem and are necessary and sufficient for its solution. It also needs to be explained why the rest of the data is redundant.



F i g u r e 5. Problem with incomplete condition

S o u r c e: Own work.

Solving this type of problem contributes to the formation of skills to compare and visually determine the inconsistency of given conditions, the ability to adjust the input data to quickly solve the problem, and the ability to see different options for solving problems with different input data, etc.



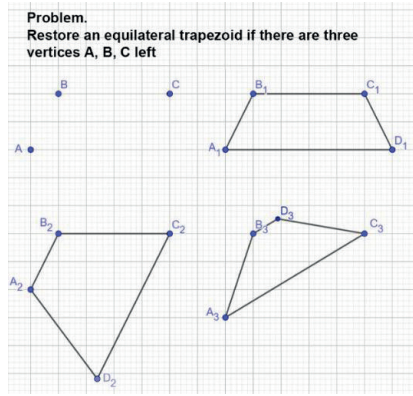
F i g u r e 6. Problem with redundant data

S o u r c e: Own work.

Visual support of such tasks if possible in programs of dynamic mathematics.

3.2.6. Using inverse tasks

We will call inverse tasks for which one of the first two elements of a chain "initial data – a method of the decision – result" is passed, that is the known method of the decision and result, but it is necessary to establish initial data (Figure 7).



F i g u r e 7. The problem of restoring the original conditions

S o u r c e: Own work.

The process of solving inverse problems consists of three stages: research (one needs to find out whether it is possible for those elements that are left, to restore the elements that are missing, or they are clearly defined), construction, proof (one needs to prove that by these constructions received exactly the right shape).

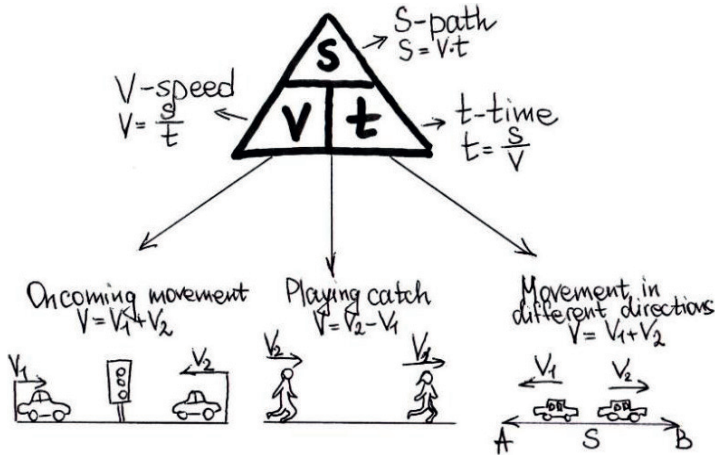
Solving such tasks not only activates educational and cognitive activities but also promotes the development of thinking flexibility, originality of thinking, develops intelligence, the ability to predict, and teaches ways in which to check results. Visual support of such tasks is possible in programs of dynamic mathematics.

3.2.7. The use of scribes

In a general sense, scribing (from the Eng. "scribe" meaning "drive a pen") – is a technology of presenting information, the essence of which is the simultaneous accompaniment of oral presentation of educational material with drawings (felt-tip pen on a whiteboard or a sheet of paper). Scribing involves a specific type of such accompaniment – illustration "on the fly", which gives a special emotionality and the ability to focus the listener on the main semantic objects. Many programs (VideoScribe, Moovly, Plotagon, Obyasnyashki) and online services (PowToon, GoAnimate, Wideo) have been developed today to create scribing presentations.

As a result of the use of scribing technology, the skills of visual interpretation, visual comparison, integration, evaluation, creation, and application of educational material presented visually are formed; the skills of visual communication, skills of transmission, perception, and understanding of education content using scribe technology are formed (Figure 8).

Thus, we have identified seven different ways to use specialized software to develop visual thinking: 1) organization of visual search through tasks visualized in the virtual environment; 2) use of tasks aimed at developing the ability to put forward visual hypotheses; 3) use of tasks aimed at identifying visual originality in solving them; 4) usage of cognitive-visual graphics; 5) use of tasks with incomplete conditions and tasks with redundant data; 6) usage of inverse tasks; and 7) use of scribing. These ways were subjected to expert evaluation in order to determine the most effective of them.



F i g u r e 8. Scribe «Tasks on the move»

S o u r c e: Own work.

3.3. The results of the experiment

According to the results of expert assessment, the two most effective ways of influencing the development of visual thinking were identified: the organization of visual search through the tasks visualized in the virtual environment, and the use of cognitive-visual graphics.

This is confirmed by the results of statistical evaluation based on Kendal's concordance coefficient (Table 1).

T a b l e 1

Expert ratings

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Total rating
Way 1	1	3	2	1	1	2	**10**
Way 2	3	4	4	4	6	4	25
Way 3	5	5	6	7	7	7	37
Way 4	2	1	3	3	2	1	**12**
Way 5	7	7	5	6	5	6	36
Way 6	4	6	7	5	4	5	31
Way 7	6	2	1	2	3	3	17

S o u r c e: Own work.

The concordance coefficient was estimated at 0.75, which indicates the consistency of experts' opinions. The statistical analysis of the obtained data also confirms a statistically significant conclusion about the consistency of expert opinion $\chi^2_{emp} = 26.86 > 11.07 = \chi^2_{critical}$.

Thus, the pedagogical experiment was built using two ways: 1) the organization of visual search through the tasks visualized in the virtual environment; and 2) the use of cognitive-visual graphics.

The experimental training took place during September–November 2019 among 3rd- and 4th-year students, as well as high school students. The training of 104 students in total took place within the special courses "The use of computer in the study of mathematics" and "Computer-oriented systems of teaching mathematics and computer science". The training of 98 high school took place within the extracurricular activities conducted by undergraduate students during internship. The result of Raven's test at the beginning and end of the experiment are presented in Table 2.

Table 2

The results of diagnostic sections in the experimental groups at the beginning and end of the experiment (in %)

	Students, before	Students, after	Pupils, before	Pupils, after
Total number	104	104	98	98
Low (71–90)	16	7	42	29
Medium (91–110)	71	76	49	48
High (111–130)	17	21	7	21
Average	100.9	103.2	93.9	98.6

Source: Own work.

Table 3

Statistical evaluation of average at the beginning and end of the experiment

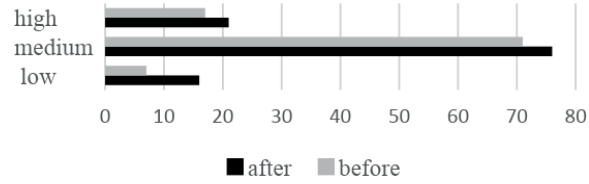
Students	Before	After	Pupils	Before	After
Average	100.9	103.2	Average	93.9	98.6
Number	104	104	Number	98	98
Hypothesis H_0:			Hypothesis H_0:		
Averages the same	0.0		Averages the same	0.0	
t-empirical	–3.75		t-empirical	–5.85	
t critical	1.98		t critical	1.98	

Source: Own work.

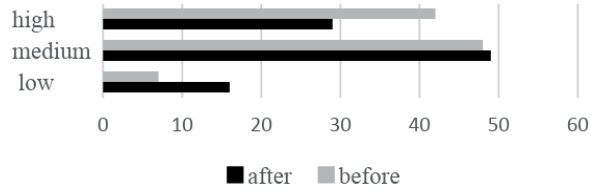
The statistical analysis of averages in groups of students and pupils by Student's t-test gives grounds to reject the null hypothesis and to accept an alternative statistical difference between the averages at the beginning and end of the experiment (calculations were performed using the tools of the analysis package of MS Excel at the significance level of 0.05).

At the same time, the analysis of the dynamics of averages (+2.3 in students against +4.7 in pupils) shows better results of changes for pupils, which is explained by more flexible cognitive skills in adolescence (see Figure 9, 10).

At the beginning of the experiment, the indicators for a group of students is mainly at high and medium levels. We explain this by high initial values, as the same consisted of students majoring in "Secondary Education (Mathematics)" and "Secondary Education (Computer Science)" in which the level of development of visual thinking, spatial thinking, logical thinking is a priori above average.



F i g u r e 9. Diagrams of levels of development of visual thinking of students
S o u r c e: Own work.



F i g u r e 10. Diagrams of levels of development of visual thinking of pupils
S o u r c e: Own work.

Note, that despite the not very high dynamics of changes, we show that the researchers with high performance at the end of the experiment offer original hypotheses about non-traditional ways of using cognitive-visual models in the educational process.

CONCLUSION

Among the possible ways to use specialized software for the development of visual thinking are the organization of visual search through tasks visualized in a virtual environment; use of tasks aimed at developing the ability to put forward visual hypotheses; use of tasks aimed at identifying visual originality in solving them; use of cognitive-visual graphics; use of tasks with incomplete conditions and tasks with redundant data; and use of inverse tasks.

For the realization of the specified ways, it is expedient to use the specialized software, namely programs of dynamic mathematics, Smart-objects from a package of office programs, means of creation of infographics, graphic editors.

Expert assessment of these ways and the statistical analysis of the results of the pedagogical experiment confirmed the feasibility of the development of visual thinking in young people; the organization of visual search through visualized tasks in the virtual environment and the use of cognitive-visual graphics, and better dynamics were observed in pupils (+2.3 in students against +4.7 in pupils), which indicates the feasibility of using these ways in general secondary education.

REFERENCES

A b d u l l a h, N., H a l i m, L., Z a k a r i a, E. (2014). VStops: A Thinking Strategy and Visual Representation Approach in Mathematical Word Problem-Solving toward Enhan-

cing STEM Literacy. *Eurasia journal of mathematics science and technology education*, *3*(10), 165–174.

A n d e r s o n I n m a n, L., H o r n e y, M. (1996). Computer-based concept mapping: Enhancing literacy with tools for visual thinking. *Journal of Adolescent & adult literacy*, *4*(40), 302–306.

A r n h e i m, R. (1994). *In Defense of Visual Thinking: New Essays on the Psychology of Art*. Moscow: Prometheus.

A s t a f i e v a, M., B o d n e n k o, D., P r o s h k i n, V. (2019). Using computer-oriented geometry means in the process of critical thinking formation of future mathematics teachers. *Information technologies and learning tools*, *3*, 102–121.

D a l i n g e r, V. A. (2006). *Theoretical bases of cognitive-visual approaches to teaching mathematics*. Omsk: Publishing house of OSPU.

I v a n y u t a, O. V. (2003). Psychological features of the development of visual thinking in adolescence (Doctoral dissertation). V. N. Karazin Kharkiv National University, Kharkiv.

K l e p k o, S. F. (1998). *Integrated education and polymorphism of knowledge. Kyiv – Poltava – Kharkiv: PRIPPE*.

K n y a z e v a, O. O. (2003). *Implementation of a cognitive-visual approach to teaching high school students the basics of mathematical analysis* (Doctoral dissertation). Omsk: Publishing house of OSPU.

K r u t e t s k y, V. A. (1968). *Psychology of mathematical abilities of pupils. Moscow: Prosveschenie*.

M o e l l e r, M., C u t l e r, K., F i e d l e r, D. (2013). Visual thinking strategies = creative and critical thinking. *Phi Delta Kappan*, *3*(95), 56–60.

M o n e s H a t t a l, B., M a n d e s, E. (1995). Enhancing visual thinking and learning with computer graphics and virtual environment design. *Computers & Graphics*, *6*(19), 889–894.

Raven's test. The scale of progressive matrices. Retrieved from https://psycabi.net/testy/717-test-ravena-progressivnye-matritsy-raven-progressiv-matrices-metodiki-dlya-diagnostiki-intellekta-vzroslykh/ (accessed 11 June 2020).

R e z n i k, N. A. (1997). Methodical bases of teaching mathematics in high school with the use of means of the development of visual thinking (Doctoral dissertation). Institute of Productive Learning of the Russian Academy of Education, St. Petersburg.

S e m e n i k h i n a, O., D r u s h l y a k, M., B o n d a r e n k o, Yu., K o n d r a t i u k, S., D e h t i a r o v a, N. (2019). Cloud-based service GeoGebra and its use in the educational process: the BYOD-approach. *TEM JOURNAL – Technology, Education, Management, Informatics*, *1*(8), 65–72. DOI: 10.18421/TEM81-08.

S y m o n e n k o, S. M. (2005). Psychology of visual thinking (Doctoral dissertation). V. N. Karazin Kharkiv National University, Kharkiv.

W a r e, C. (2004). Visual queries: The foundation of visual thinking. *International Workshop on Visual Artefacts for the Organization of Information and Knowledge, Searching for Synergies*. Tubingen: Knowledge Media Res Ctr.