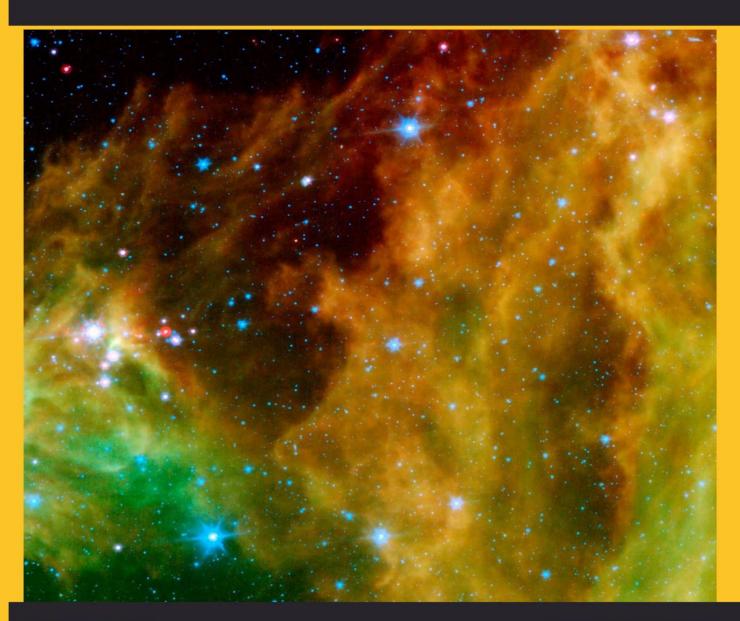
INTERNATIONAL JOURNAL OF PROFESSIONAL SCIENCE

INTERNATIONAL SCIENTIFIC JOURNAL



SCIPRO.RU ISSN 2542-1085 MOLECULAR & CELL BIOLOGY
APPLIED FINANCAL MATHEMATICS
• HUMAN-COMPUTER INTERACTION 5

International Journal Of Professional Science: international scientific journal, Nizhny Novgorod, Russia: Scientific public organization "Professional science", №2-2022. 36 p. DOI 10.54092/25421085_2022_2

ISSN 2542-1085

International journal of Professional Science is the research and practice edition which includes the scientific articles of students, graduate students, postdoctoral students, doctoral candidates, research scientists of Russia, the countries of FSU, Europe and beyond, reflecting the processes and the changes occurring in the structure of present knowledge.

It is destined for teachers, graduate students, students and people who are interested in contemporary science.

All articles included in the collection have been peer-reviewed and published in the form in which they were presented by the authors. The authors are responsible for the content of their articles.

The information about the published articles is provided into the system of the Russian science citation index − RSCI under contract № 2819-10/2015K from 14.10.2015

The electronic version is freely available on the website http://scipro.ru/ijps.html

UDC 001

LBC 72



Editorial team

Chief Editor – Krasnova Natalya, PhD, assistant professor of accounting and auditing the Nizhny Novgorod State University of Architecture and Construction. (mail@nkrasnova.ru)

Zhanar Zhanpeisova — Kazakhstan, PhD

Khalmatova Barno Turdyhodzhaeva — Uzbekistan, MD, Professor, Head of the Tashkent Medical Academy Tursunov Dilmurat Abdullazhanovich — Kyrgyzstan, PhD, Osh State University

Ekaterina Petkova, Ph.D Medical University — Plovdiv

Stoyan Papanov PhD, Department of Pharmacognosy and pharmaceutical chemistry, Faculty of Pharmacy, Medical University — Plovdiv

Materials printed from the originals filed with the organizing committee responsible for the accuracy of the information are the authors of articles

Editors N.A. Krasnova, 2022 Article writers, 2022 Scientific public organization "Professional science", 2022

Table of contents

APPLIED PEDAGOGY AND PSYCHOLOGY	5
Zak A. Formation of intellectual actions in elementary	
APPLIED SECURITY AND ANALYTICS	17
Glushkov S.V., Pronkin N.N., Semenycheva I.F. Threa	its to the
information security system Moscow megalopolis	17
SURVEYING AND LAND ECONOMY	22
Kharitonov A.L. The Deep Geophysical Research of	the Pre-
paleozoic plume-tectonic structures of the North	Eurasian
region	22
TECHNOLOGY, ENGINEERING	
Mozhzhukhina A. V. LSI element placement method k	based on
deep reinforcement learning	30

APPLIED PEDAGOGY AND PSYCHOLOGY

UDC 740

Zak A. Formation of intellectual actions in elementary school

Zak Anatoly

Leading Researcher, Psychological Institute of the Russian Academy of Education, Moscow, Russia.

Abstract. The article presents a study devoted to the study of the intellectual actions of second-grade students. The purpose of the study was to determine the conditions conducive to the formation in children of intellectual actions related to reasoning, comparison, planning and combination. It was assumed that the author's program "Gumption" is a condition for such formation. As a result of the study, it was shown that 32 lessons of the children of the experimental group according to the "Gumption" program (for nine months, one lesson per week) provided the children of the experimental group with a significant advantage in performing diagnostic tasks related to the performance of intellectual actions.

Keywords: intellectual actions, search tasks, second-graders, the program "Gumption".

DOI 10.54092/25421085_2022_2_5

Рецензент: Агронина Наталья Иосифовна— Кандидат педагогических наук, доцент, доцент кафедры социальной работы, ФГБОУ ВО «Курский государственный университет»

1.Introduction

At present, educational programs at all levels, including primary school, are becoming more complex. Mastering more complex programs requires a higher level of formation of intellectual actions. At the beginning of the 21st century, numerous studies of the problems, methods and ways of teaching thinking were carried out.

1.1 Approaches to stimulate thinking

A study by Adey, P. [2008] characterized thinking development programs for children aged 4–11 years. Dewey, J., & Bento, J. [2009] studied the results of a two-year program that activates thinking in elementary school students and noted an improvement in children's cognitive abilities and social skills, as well as an increase in the professionalism of teachers. De Acedo Lizarraga et al. [2009] showed good opportunities for stimulating intelligence, abstract and deductive reasoning in accordance with the PAEA method.

McGuinness, C. with a group of researchers [2006] analyzed the use of various types of mental tasks to stimulate cognitive skills and identified the most effective ones. Trickey, S.,

& Topping, K. J. [2004] found that the Philosophy for Children elementary school program had a positive effect on the development of reasoning and argumentation skills in elementary school students.

Lucas, B., & Claxton, G. [2010] studied different types of intelligence (social, practical, strategic, intuitive, etc.) in younger students and identified effective practical tools for teachers in accordance with the noted types of intelligence. Nisbett, R. E et al [2012] have identified the characteristics of the relationship between intelligence and self-regulation, procedural memory and cognitive skills.

The study by Kuhn, D. [2009] shows the importance of children's understanding of acquired knowledge for assessing learning outcomes. Shayer, M., & Adhami, M. [2007] demonstrated the effectiveness of developing cognitive skills in the study of mathematics. Swartz and McGuinness [2014] explored different possibilities for integrating thinking and academic learning. Puchta, H. and Williams, M. [2011] studied the development of 13 categories of cognitive skills (from simple to complex) in relation to the acquisition of significant practical language skills.

1.2. Brief description of the study

The content of the considered experimental works allows us to note that most researchers use educational material. We believe that it is possible to study the development of thinking and its stimulation on non-educational material. Such material creates favorable conditions for acquiring thinking skills, since, as our works [2004, 2003, 2015] have shown, knowledge of the curriculum does not determine the success of solving search non-standard problems (unlike solving educational problems). Underachieving children perform more confidently in solving such problems than in solving academic problems, because this new experience is not tainted by failure.

The purpose of the study was to study the conditions for the formation of intellectual actions in second-graders related to reasoning, comparison, planning and combination. Hypothesis: 32 lessons in the "Gumption" program are a condition for such formation. In our experiments [2004], it was shown that children, on their own or with little help, can solve simple variants of various types of tasks of the "Gumption" program (here it should be noted that the program under discussion was developed on the basis of our course of developmental activities for students in grades 1–4 " Intellectika" [2002].

The study consisted of three stages. At the first stage, two groups of schoolchildren (control - 69, experimental - 73) solved search tasks to determine the degree of development of mental skills. The second stage included 32 lessons in the experimental group according to

the "Gumption" program (one lesson per week). At the third stage, the children of both groups again solved the same search tasks.

2. Materials and methods

The "Gumption " program is designed to conduct 32 lessons based on 32 types of non-standard tasks with non-educational content: 9 types of plot-logical tasks, 6 types of operational-logical tasks, 8 types of spatial tasks, 9 types of route tasks. Plot-logical tasks contribute to the development of reasoning skills, operational-logical tasks - the ability to compare, spatial tasks - the ability to combine, route tasks - the ability to plan. In each lesson, children solve problems of the same type.

2.1. The content of the program «Gumption».

Lesson 1: route tasks (type 1). Lesson 2: plot-logical tasks (type 1). Lesson 3: spatial problems (type 1). Lesson 4: route tasks (type 2). Lesson 5: operational-logical tasks (type 1). Lesson 6: plot-logical tasks (type 2). Lesson 7: spatial problems (type 2). Lesson 2k 8: route tasks (type 3). Lesson 9: plot-logical tasks (type 3). Lesson 10: operational-logical tasks (type 2). Lesson 11: spatial problems (type 3). Lesson 12: route tasks (type 4). Lesson 13: plot-logical tasks (type 4). Lesson 14: spatial problems (type 4). Lesson 15: operational-logical problems (type 3). Lesson 16: route tasks (type 5). Lesson 17: plot-logical tasks (type 5). Lesson 18: spatial problems (type 5). Lesson 19: route tasks (type 6). Lesson 20: operational-logical tasks (type 4). Lesson 21: plot-logical tasks (type 6). Lesson 22: route tasks (type 7). Lesson 23: spatial problems (type 6). Lesson 24: plot-logical tasks (type 7). Lesson 25: operational-logical tasks (type 5). Lesson 26: route tasks (type 8). Lesson 27: spatial problems (type 7). Lesson 28: plot-logical tasks (type 8). Lesson 29: route tasks (type 9). Lesson 30: operational-logical problems (type 6). Lesson 31: plot-logical tasks (type 9). Lesson 32: spatial problems (type 8).

2.2. Plot-logical tasks.

9 types of plot-logic tasks have the following content.

Type 1, for example: "Dima, Liza and Borya swam across the river. Dima swam faster than Lisa. Lisa swam faster than Borya. Who swam the fastest? »

Type 2, for example: "Words CUTE, CORPS, DOVE in different colors. Blue and pink words have the same first letter, pink and red words have the same second letter. What word is blue?

Type 3, for example: "Edik and Leva are of different ages. In many years, Edik will be a little older than Leva is now. Which one is younger? »

Type 4, for example: "Petya, Yura and Sasha sent letters: two to Ufa, one to Kazan. Petya and Yura, Yura and Sasha sent letters to different cities. Where did Petya send his letter?

Type 5, for example: "Three words were written in blue, red and gray paint: WOOD, CROW, RAINBOW. The blue word is to the left of the red word, and the gray word is to the right of the red word. What color is the word CROW? »

Type 6, for example: "Dima and Katya had cubes with letters. First, Dima made up the word DOM. Then he moved the letters and got the word MOD. Katya first composed the word CAT, and then moved the letters in the same way as Dima. What word did Katya get?"

Type 7, for example: "Three cats lived in the house - gray, white and black: one in the room, one in the hall, one in the attic. In the morning they fed either a black cat or a cat in the attic, in the evening either a cat in the attic or a white cat. Where did the gray cat live?"

Type 8, for example: "Ira, Yulia and Anya received a doll each. One doll was wearing a long-sleeved red dress, another was wearing a short-sleeved red dress, and the third was wearing a long-sleeved green dress. The dresses of Ira and Yulia dolls were of the same color, and Yulia and Anya's dolls had dresses with the same sleeves. Who had a doll in a red dress with long sleeves?"

Type 9, for example: "Lena and Dasha went to a sports store. Both bought one pair of skis and one pair of skates. Some of the girls liked alpine skiing, some - cross-country skiing, some - roller skates, some - figure skates. Lena left the store without skis. The girl who chose alpine skiing did not buy figure skates. Who bought roller skates?"

At each lesson, children solve 3 variants of tasks of the same type: 1) find the answer, 2) find the question, 3) find part of the conditions.

Option 1 is shown in the examples above.

Option 2, for example: "Dima, Lesha and Borya trained in high jumps. Dima jumped higher than Leni. Dima jumped higher than Borya. Which question can be answered, taking into account the conditions of this problem: a) Who jumped higher than Bori? b) In what style did Borya jump? c) Who jumped below Sloth?"

Option 3, for example: "Gena, Leva and Vova swam across the river. Gena swam faster than Leva. [...]. Who swam the fastest?"

What should be added to the conditions of the problem to answer her question: (a) [Vova swam faster than Gena]. (b) [Vova swam as fast as Gena]. (c) [Leva swam faster than Vova].

2.3. Operational-logical tasks.

6 types of tasks for comparing schematic representations of objects have the following contents.

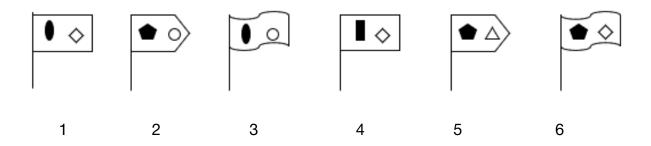


Fig.1. The flags

Type 1, for example: "Consider flags 2, 3, 6. Which flag is similar in shape to flag 6?"

Type 2, for example: "Flags 1, 3, 5. Which flag has the same feature as flag 5?"

Type 3, for example: "Flags 1, 4, 5. Which flag, 4 or 5, has more of the same features as flag 1?"

Type 4, for example: "Flags 2, 3, 6. Which flag, 2 or 3, is similar in shape to flag 6 but has a dark figure like flag 1?"

Type 5, for example: "Flags 1, 3, 6. Which flag, 1 or 3,A has one identical feature with flag 1 and one identical feature with flag 6?"

Type 6, for example: "Flags 1 - 6". Flags 1 and 6 have the same feature. Which two flags - 2 and 3 or 1 and 4 - have more of the same features than flags 1 and 6?"

At each lesson, children solve 3 options for tasks for tasks of the same type: 1) find the answer, 2) find the question, 3) find part of the conditions.

Option 1 is shown in the examples above.

Option 2, is to find a question, for example: "Flags 2, 3, 6. Which question is appropriate for the answer "Flag 2": (a) Which flag has a dark figure, such as flag 2? (b) Which flag has a light figure such as flag 3? (c) Which flag has the shape of flag 6?"

Option 3, find part of the conditions, for example: "Flags 3, 6. Which flag has such a light figure as flag 6?" Which third flag is needed to answer this question: (a) flag 2, (b) flag 5, (c) flag 4.

2.4. Spatial tasks.

8 types of spatial problems have the following content.

Type 1, for example: "How can the arrangement of letters |C||R| change in two moves so that the following arrangement is obtained: |R|C||?"

Rule: one move is the movement of any letter to an empty space.

Type 2, for example: "How can I arrange the letters |R|R|C| | change in two moves so that the following arrangement of numbers is obtained |7|7| | 4|?

Rule: 1) one move is the movement of any letter to an empty space; 2) the same letters must be placed in the same way as the same numbers.

Solution: | R | R | C | | ... | | R | C | R | ... | C | R | | R |.

Type 3, for example: "How the arrangement of letters |H| |V| |C| change in two steps to get the location |H|V|C|?"

Rule: one action is the mental movement of any letter to an empty space. Solution: 1. | H | | V | | C | --- | H | V | | C |; 2. | H | V | | C | --- | H | V | C | or | H | | V | | C | --- | H | V | | C | --- | H | V | C | : the first action moves the letter H to an empty space, the second action moves the letter C to an empty space.

Type 4, for example:: "How the arrangement of letters |K| |K| |F| change in two steps so that the letters are arranged in the same way as the numbers |8|4|?"

Rule: 1) one action is the mental movement of any letter to a free space; 2) the same letters as a result of two actions should be located in the same way as the same numbers.

Type 5, for example: "How can you change the arrangement of the letters PMK in two moves to get the arrangement KPM?"

Rule: one move is the simultaneous exchange of two letters.

Solution: PMK ... RMB ... KPM: first, the letters M and K are reversed, then the letters P and K.

Type 6, for example: "How can you change the arrangement of the letters PPMK in two moves to get the arrangement of the numbers 6855?"

Solution: PMMK... PMMK... PKMM.

Type 7, for example:: "How is the arrangement of letters and numbers | R | G | |7 | change in two steps to get the location | | G | 7 | R | ?"

Solution: | R | G | | | 7 | --- | R | G | 7 | | --- | | G | 7 | R |.

Type 8, for example:: "How is the arrangement of letters and numbers | 7 | H | | H | change in two steps to get the location of the signs | # | # | % | | ?"

Solution: |7 | H | | H | --- | | H | 7 | H | --- | H | H | 7 | |.

At each lesson, children solve 3 variants of tasks of the same type: 1) find the answer, 2) find the final location, 3) find the initial location.

Option 1 is shown in the examples above.

Option 2, for example: "Which of the following two locations will be: a) |C| R | or b) |C| P |, if in the location |R| C | make two permutations of letters in a free cell?" Option 3, for example: "What was the location: a) |C| R |C| P |C| if after two moves the arrangement |C| P |C|?"

2. 5. Route tasks.

Below is the content of 9 types of tasks related to the movement of imaginary characters according to certain rules.

Α	В	С	D	Е
F	G	Н	Ι	J
к	L	М	N	0
Р	Q	R	S	Т

Fig.2. Playing field 1

Type 1, e.g.: ""What two steps did the chicken take to get from K to R?"

Rule: 1) "Chicken", an imaginary character, moves through the letters in the "cells" of the "square"; 2) the characteristics of its movements are: (a) it steps directly, i.e., into a neighboring cell vertically (e.g.: from M to H or to R) or horizontally (e.g.: from M to N or L); (b) it steps obliquely, i.e., diagonally,(e.g.: from M to G or I or S or Q); 3) duck can not make two identical steps (two direct steps or two oblique steps) in succession. Solution: K...L...R.

Type 2, e.g.: "What two jumps did the take dog to get from K to E?"

Rule: 1) "Dog", an imaginary character, moves through the letters in the "cells" of the "square"; 2) the characteristics of its movements are: (a) it jumps directly, i.e., through the letter vertically (e.g.: from M to C or W) or horizontally (e.g.: from M to K or O); (b) it jumps obliquely, i.e., diagonally, e.g.: from M to E or A or U or Y; 3) hare can not make two identical jumps (two direct jumps or two oblique jumps) in succession. Solution: K...M...E.

Type 3, e.g.: "What two jumps did the cat take to get from K to S?"

Rule: 1) "Cat", an imaginary character, moves through the letters in the cells of the square; 2) the characteristics of its movements are as follows: it jumps through the letter (e.g.: from M to F or B or D or J or T or X or V or P). Solution: K...V...S.

Type 4, e.g.: "What two moves do the chicken k (directly) and the dog (obliquely) need to make in order to get from G to T?" Solution: G...H...T.

Type 5, e.g.: "What two moves do the chicken (obliquely) and the dog (directly) need to make in order to get from H to S?" Solution: H...G...V.

Type 6, e.g.: "What two moves do the chicken (directly) and the cat need to make in order to get from B to J?" Solution: B...C...J.

Type 7, e.g.: "What two moves do the chicken (obliquely) and the cat need to make in order to get from D to Q?" Solution: D...H...Q.

Type 8, e.g.: "What two moves do the dog (directly) and the cat need to make in order to get from R to E?" Solution: R...H...E.

Type 9, e.g.: "What two moves do the dog (obliquely) and the cat need to make in order to get from G to V?" Solution: G...S...V.

At each lesson, children solve 3 variants of tasks of the same type: 1) find the answer, 2) find the final cell of displacements, 3) find the initial cell of displacements.

Option 1 is shown in the examples above.

Option 2, for example: "Which cell did the duck get two steps from C: cell W or cell O?"

Option 3, for example: "From which cell did the duck get to Y in two steps: from cell X or K?"

2.6. Features of developing activities.

The lesson on the program «Gumption» consists of three parts. In the first part (about 15 minutes), the teacher, together with the students, analyzes ways to solve a typical problem. Children need to understand what to look for in this type of problem and how it can be achieved. To do this, they are given the tools to analyze problems and ways to manage the search for solutions and control their actions.

In the second part (about 30 minutes), children independently solve 12 to 15 problems, applying the knowledge gained in the first part. In the third part (about 15 minutes), the teacher, together with the students, checks the solved problems and considers incorrect solutions, once again demonstrating the methods of problem analysis and ways to control mental activity.

3. Results

3.1. Diagnostics of thinking skills.

Before and after 32 classes, group diagnostics were carried out on the basis of search tasks, in which it was necessary to find the movement of the "Postman" between the "houses" on the playing field (fig.3):

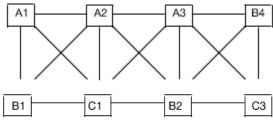


Fig.3. Playing field 2

The "Postman" moves according to the following rule: if two neighboring "houses" have the same "resident" - a letter or number (for example, houses A2 and B2 or A2 and A3), then you can walk along the path between such houses; if - the "houses" do not have the same "resident" (for example, A2 and B3), then - you can't go.

For example, such a problem: "What two moves does the Postman need to make to get from A2 to C3 (A2...?... C3)?" Solution: A2...A3...C3.

After explaining the Postman's movement rule, it was proposed to solve six problems:

- (1)A1...? ...B2;
- (2) IN 1...? ... A2;
- (3) B2...? ...? ...C3;
- (4) A3...? ...? ...B4;
- (5) C1...? ...? B4;
- (6) B4...? ...? ...? ...B1.

3.2. The main results of the study.

Quantitative characteristics of the success of solving diagnostic problems by second-graders are presented in the table.

Table.

Children of the control and experimental groups who solved six problems in September and May (in %)

Groups	September	May	
Control	23,2	34,8	
Experimental	20.5**	57.5**	

Note: **p<0.01

According to the data presented in the table, the level of development of mental skills in May increased (compared to September) in both groups: by 11.6% in the control group, by 37.0% in the experimental group. In September, the difference was minimal - 2.7%, and in May it became statistically significant - 22.7% (at p <0.01). Thus, the conducted study confirmed the initial hypothesis that the "Gumption" program contributes to the formation of intellectual actions in second-graders.

4. Discussion

4.1. Experimental conditions.

The results obtained in the study are explained by the peculiarities of the content of the "Gumption" program: the non-educational content of tasks, their search nature, the variety of their types (plot-logical tasks, operational-logical, spatial, route), structural differences and differences in tasks: find an answer, find a question, find part of the condition.

The specific characteristics of the implementation of the "Gumption" program are also important: 32 hour sessions held weekly for nine months. Each lesson consists of three parts - preliminary discussion, independent problem solving, final discussion.

The subjects were ordinary students in ordinary classes of two ordinary schools. The control group consisted of two classes in one school and one class in another school, while the experimental group consisted of one class in the first school and two classes in the second school.

Classes were conducted by ordinary elementary school teachers.

- 4.2. Scientific significance of the study As a result of the experiments, new knowledge was obtained about the conditions for the formation of mental skills, expanding and clarifying the ideas of developmental psychology about the possibilities of intellectual development of younger students.
 - 4.3. The influence of developmental activities.

Observations of the actions of students testified to changes in their behavior: they were no longer afraid of mistakes, offering their own solutions. Children who failed to solve all six diagnostic tasks in September initially showed increased anxiety, but subsequently gained more confidence and became more active in discussions.

When solving problems independently, these children were supported for eight lessons: the teacher reminded them of the rules for solving specific types of problems, indicated the elements of the conditions that must be taken into account, and helped them understand errors in incorrect solutions.

The students who solved all the problems in September were also supported: the teacher offered to compose problems similar to those solved. As our studies show [2003], [2016], such tasks contribute to the development of mental skills and creative thinking.

In conversations with teachers, it was noted that they made certain changes in their work. In particular, they began to offer more problems with incomplete conditions or missing questions, and also gave children problems that required verification of the finished solution. Speaking about changes in the behavior of students in the lessons according to the school curriculum, teachers noted the increased activity of children in class discussions, emphasizing the fact that children began to reason more consistently when solving mathematical problems and give more examples when studying grammar rules).

4.4. Research limitations.

In September, on average, 21.8% of students solved six problems in both groups. With a different composition of the group, where the results were, for example, 15.0% or 10.0%, the effectiveness of developmental classes could be lower.

The pedagogical experience of the teachers who conducted the classes was, on average, 15-20 years, whereas if it had been 3-5 years, the development of the children in the experimental group would have been less effective.

4.5. Goals of further research

Conduct a similar study with third-graders to more fully and accurately assess the impact of the «Gumption» program on the development of thinking skills in children of primary school age.

Determine the optimal composition of the search tasks for each age level of the «Gumption» program and check the effectiveness of other types of tasks.

To study new options for the frequency of developmental classes per month, as well as the duration of one lesson and its three parts. It is important to investigate the impact on the effectiveness of developmental activities of the number of children in the class, as well as their composition based on the results of the initial diagnosis.

Create a comprehensive program for the formation of intellectual activity among younger schoolchildren, in which the "Ingenuity" program would serve as propaedeutics in the course of the development of critical and creative thinking [2016].

5. Conclusion

The study demonstrated the effectiveness of the development of thinking skills in second-graders in group activities, when on a regular basis (once a week) for nine months (from September to May) various types of search tasks of non-educational content included in the "Gumption" program were solved.

References

- 1. Adey, P., (Ed.), (2008). *Let's think handbook: A guide to cognitive acceleration in the primary school.* London: GL Assessment.
- 2. De Acedo Lizarraga, M., De Acedo Baquedano, M., Goicoa Mangado, T., & Cardelle-Elawar, M. (2009). Enhancement of thinking skills: Effects of two intervention methods. *Thinking Skills and Creativity, 4*(1), 30-43.
- 3. Dewey, J., & Bento, J. (2009). Activating children's thinking skills (ACTS): The effects of an infusi4on approach to teaching thinking in primary schools. British Journal of *Educational Psychology*, 79(2), 329-351.
- 4. Kuhn, D. (2009). The importance of learning about knowing: Creating a foundation for development of intellectual values. *Child Development Perspectives, 3*(2), 112-117.
- 6. Lucas, B., & Claxton, G. (2010). *New kinds of smart: How the science of learnable intelligence is changing education.* Maidenhead, UK: McGraw-Hill International.
- 7. McGuinness, C., Sheehy, N., Curry, C., Eakin, A., Evans, C., & Forbes, P. (2006). Building thinking skills in thinking classrooms. ACTS (Activating Children's Thinking Skills) in Northern Ireland. London, UK: ESRC's Teaching and Learning Research Programme, Research Briefing No 18.
- 8. Nisbett, R. E., Aronson, J., Blair, C., Dickens, W., Flynn, J., Halpern, D. F., et al. (2012). Intelligence: New findings and theoretical developments. *American Psychologist*, *67*(2), 130-159.
- 9. Puchta, H. and Williams, M. (2011). *Teaching Young Learners to Think*. Innsbruck and Cambridge: Helbling Languages and Cambridge University Press.
- 10. Shayer, M., & Adhami, M. (2007). Fostering cognitive development through the context of mathematics: Results of the CAME project. *Educational Studies in Mathematics*, *64*(3), 265-291.
- 11. Swartz, R. and McGuinness, C. (2014). *Developing and Assessing Thinking Skills*. Project Final Report Part 1 February 2014 with all appendices.
- http://www.ibo.org/globalassets/publications/ib-research/continuum/student-thinking-skills-report-part-1.pdf
- 12. Trickey, S., & Topping, K. J. (2004). Philosophy for children: A systematic review. Research Papers in Education, 19(3), 365-380.
 - 13. Zak A. (2002).Intellectika. M.: Intellect-Centr [in Russian].
- 14 Zak A. (2003). Characteristics of individual differences in the thinking of younger students. Sankt-Peterburg: Piramida [in Russian].
- 15. Zak A. (2004). Thinking of the younger school student. Sankt-Peterburg: Sodeystvie [in Russian].
- 16. Zak A. (2015). Improvement of cognitive and regulatory actions in elementary school. Sankt-Peterburg: Proekcia [in Russian].
- 17. Zak A. (2016). Development of author's thinking in younger schoolchildren. Moscow: Biblio-Globus [in Russian].

APPLIED SECURITY AND ANALYTICS

UDC 33

Glushkov S.V., Pronkin N.N., Semenycheva I.F. Threats to the information security system Moscow megalopolis

Glushkov S.V.,

PhD, associate Professor – Sechenov First Moscow state medical University of the Ministry of health of the Russian Federation (Sechenov University).

Pronkin N.N.,

PhD, associate Professor – Sechenov First Moscow state medical University of the Ministry of health of the Russian Federation (Sechenov University).

Semenycheva I.F.,

PhD, associate Professor – Sechenov First Moscow state medical University of the Ministry of health of the Russian Federation (Sechenov University).

Abstract. The article discusses issues related to the integrated development and implementation of new technologies from the perspective of reducing threats to the information security system.

Keywords: information security system; information system; technology; availability; threats; metropolis.

DOI 10.54092/25421085 2022 2 18

Рецензент: Бессарабов Владислав Олегович - Кандидат экономических наук. ГО ВПО «ДонНУЭТ имени Михаила Туган-Барановского»

The current stage of society's development is characterized by a significant increase in the role of information and communication technologies (ICT) in the activities of commercial and public institutions and the daily lives of citizens. In these conditions, the vulnerability of ICT has given rise to new types of counter-actions, such as cybercrime and cyberterrorism, and has brought to life a new form of confrontation – information warfare. Threats related to ICT are relevant for all States involved in information interaction. The problem of security of information resources acquires global significance, characteristic of each structural level of the world community and field of activity.

The increase in the world's urban population over the past 10 years has been approximately 40%. Such an increase causes an increased burden on all services that ensure the functioning of the urban economy. At the same time, many technologies that ensure the

vital activity of Russian cities have exhausted their capabilities to serve the rapidly growing urban population.

Among the trends in technology development in Russia and around the world, the development of highly organized systems is at the forefront. The leaders of the largest Russian cities are striving to optimize the urban environment, traffic flows, and create a more efficient urban infrastructure management system. Today in Russia there is an "Electronic government" that improves the communication of the city administration, various institutions and residents. This system makes it possible to manage the city, allows you to get a large amount of information for making management decisions.

There are also projects in the energy industry to improve the system of production, distribution and consumption of electricity, for which sensors, smart devices connected to the Internet are necessary. They make it possible to better optimize the production, consumption and distribution of electricity, and reduce the negative impact on the environment.

To achieve this goal, the introduction of new information technologies is required, which are one of the important elements of the functioning of modern cities. There is an introduction of automated management and control systems for various spheres of city life, such as housing and communal services, urban automobile traffic, public transport, tourism, public safety, education, healthcare, energy supply, water supply, environmental situation.

The comprehensive introduction of modern information technologies contributes to a significant improvement in the quality and efficiency of the provision of educational, medical and other social services and contributes to an increase in the level of information security.

But the positive dynamics of the development of systems entails issues of information protection. Threats to information security are changing no less actively. The use of highly efficient technologies inevitably leads to the strengthening of existing threats and the emergence of new ones.

A threat is a potential opportunity to violate information security, which is usually considered as a combination of three aspects: Accessibility, Integrity and Confidentiality.

Violation of any of them leads to harmful effects on information and other resources of the system. Within the framework of production information systems, the distribution of protective actions between aspects is equal, that is, in such systems, a third of all information security efforts are mobilized to protect Accessibility, Integrity and Confidentiality account for the other two thirds.

The role of Accessibility is increasing due to the change in the list of threats. For sensors, sensors and other devices, accessibility is vital, since this property of data provides the possibility of their arbitrary use in solving problems.

The list of threats related to the human factor is significantly reduced. Currently, the powerful threat stream "Unintentional errors of regular users" reaches 65%, and "smart systems" significantly reduce this value by at least half.

The threats associated with failures of the supporting infrastructure (failures of communication systems, power supply, water and heat supply, air conditioning, destruction of the building, failure of maintenance personnel) are noticeably reduced, and the threats associated with failures of the system itself and user failures are clearly increasing.

User rejections:

- unwillingness to work with the information system (most often manifests itself when it is necessary to master a new one);
- inability to work with the system, as there is no appropriate training;
- inability to work with the system due to lack of technical support (incomplete documentation, inability to obtain reference information).

Failures of the system itself for internal reasons:

- deviation from the established rules of operation (accidental or intentional);
- system out of normal operation due to accidental or intentional actions of users or maintenance personnel (exceeding the estimated number of requests, excessive amount of information processed, etc.);
- errors during (re) configuration of the system;
- software and hardware failures;
- data destruction;
- destruction or damage of equipment.

Currently, the introduction of modern information technologies in urban development strategies involves a radical restructuring in the management system of municipalities, a reassessment of Russia's resources and the search for new ways to achieve this goal.

A safe city is a city in which the existing resources of city services are used in the best possible way, providing services of the best quality for city residents and ensuring maximum safety of city life, for which information and communication technologies are widely used.

Smart services in the field of housing and communal services, transport service management, the formation of unified urban information systems are successfully functioning in Moscow, systems are being implemented in the field of security and rational management of urban communal services.

To solve the tasks set, a completely new integrated approach is required, including the unification of technical and humanitarian components of the problems of ensuring urban security. Safe technologies of critical infrastructures, secure telecommunications and security of every citizen, including his personal data, work on education and instilling a moral way of life – this is the foundation on the basis of which it is necessary to build such a complex sociotechnical object as a safe city.

The composition and structure of threats associated with failures of the supporting infrastructure of the urban economy are changing due to the development and implementation of modern technologies. An unsystematic approach, the introduction of individual modern technologies, and the lack of communication between urban household technologies lead to an increase in the level of threats to information security.

Thus, when planning investments related to the development and implementation of modern technologies, it is necessary to take into account the costs of accessibility protection to a greater extent, to ensure the neutralization of numerical threats, to provide for the costs of researching potential threats from new technologies.

References

- 1. Владимирова Т.А., Соколов В.Г., Соколов С.А. Надежность функционирования и развития экономических систем с высоким технологическим укладом // Сибирская финансовая школа. 2015. № 6 (113).
- 2. Галатенко В.А. Основы информационной безопасности: курс лекций: учебное пособие / В.А. Галатенко. Москва, 2006.
- 3. Глущенко В.М., Новиков А.Н., Пронькин Н.Н. Особенности формирования и содержания модели управления московским мегаполисом. Информационные и телекоммуникационные технологии. 2019. № 44. С. 32-37.
- 4. Денисов В.В. Анализ состояния защиты данных в информационных системах: учебно-методическое пособие / В.В. Денисов. Новосибирск, 2012.
- 5. Дрожжинова В.А. Умные города: потенциал и перспективы развития в регионах России. Эл. ресурс https://irsup.hse.ru/news/120291071.html.
- 6. Информационная безопасность мегаполиса на примере города Москвы. Монография / Н.Н. Пронькин М.: ООО «Экслибрис-Пресс», 2017.
 - 7. Как построить умный город / Эл. ресурс http:city-smart.ru/info/123.html.
- 8. Калачанов В.Д., Ефимова Н.С., Новиков А.Н., Пронькин Н.Н. Внедрение систем диспетчирования производства на высокотехнологичных предприятиях (на примере предприятий авиастроения). Инновации и инвестиции. 2019. № 3. С. 269-273.
- 9. Калачанов В.Д., Новиков А.Н., Калачанов В.В., Пронькин Н.Н. Критерии оптимального управления финансированием производственной деятельности предприятий высокотехнологичных отраслей промышленности (на примере авиастроения). Организатор производства. 2016. № 1 (68). С. 61-68.
- 10. Калачанов В.Д., Новиков А.Н., Калачанов В.В., Пронькин Н.Н. Разработка комплексной системы критериев оптимизации финансирования производственной

деятельности промышленных предприятий (на примере авиастроения). Организатор производства. 2016. № 3 (70). С. 50-61.

- 11. Коммуникации / Эл. ресурс http:city-smart.ru/info/94.html.
- 12. Новиков А.Н., Пронькин Н.Н. Внедрение инструментальных методов в управление экономикой предприятий ОПК. Вестник Академии военных наук. 2014. № 3 (48). С. 148-152.
- 13. Пронькин Н.Н. Инструментарий управления системой производства продукции ОПК. Вестник Академии военных наук. 2015. № 1 (50). С. 147-150.
- 14. Пронькин Н.Н. Практика внедрения системы дистанционного обучения в МГУУ Правительства Москвы на основе E-learning 3000. Информационные и телекоммуникационные технологии. 2011. № 12. С. 72-78.
- 15. Пронькин Н.Н., Новиков А.Н. Программно-математические методы обоснования потребности в экономических ресурсах для выполнения государственного оборонного заказа. Вестник Академии военных наук. 2014. № 4 (49). С. 122-125.
- 16. Свидетельство о государственной регистрации программы для ЭВМ № 2020614011 Российская Федерация. Программа коррекции прямых наборов данных: № 2020612947: заявл. 17.03.2020: опубл. 25.03.2020 / Н. Н. Пронькин.
- 17. Свидетельство о государственной регистрации программы для ЭВМ № 2020614012 Российская Федерация. Программа настройки моделирующего комплекса на нужные имена баз данных: № 2020612945: заявл. 17.03.2020: опубл. 25.03.2020 / Н. Н. Пронькин.
- 18. Свидетельство о государственной регистрации программы для ЭВМ № 2020614013 Российская Федерация. Программа подготовки матриц коэффициентов соизмеримости: № 2020612944: заявл. 17.03.2020: опубл. 25.03.2020 / Н. Н. Пронькин.
- 19. Свидетельство о государственной регистрации программы для ЭВМ № 2019661181 Российская Федерация. Моделирующий комплекс информационных и расчетных задач: № 2019660121: заявл. 14.08.2019: опубл. 21.08.2019 / Н. Н. Пронькин.
- 20. Свидетельство о государственной регистрации программы для ЭВМ № 2019663074 Российская Федерация. Программа обработки и вывода результатов моделирующего комплекса: № 2019661592: заявл. 20.09.2019: опубл. 09.10.2019 / Н. Н. Пронькин.
- 21. Свидетельство о государственной регистрации программы для ЭВМ № 2019667818 Российская Федерация. Программа загрузки баз данных моделирующего комплекса: № 2019666753: заявл. 17.12.2019: опубл. 30.12.2019 / Н. Н. Пронькин.
- 22. Свидетельство о государственной регистрации программы для ЭВМ № 2019667819 Российская Федерация. Программа формализованной карты моделирующего комплекса: № 2019666755: заявл. 17.12.2019: опубл. 30.12.2019 / Н. Н. Пронькин.
- 23. Турко Н.И., Пронькин Н.Н. АВН: 20 лет создания инноваций для обороны России. Научно-исторический очерк / Москва, 2015.

SURVEYING AND LAND ECONOMY

UDC 550.3+551.4+551.242

Kharitonov A.L. The Deep Geophysical Research of the Prepaleozoic plume-tectonic structures of the North Eurasian region

Глубинные геофизические исследования Допалеозойских плюм-тектонических структур Северо-Евразийского региона

Kharitonov Andrey Leonidovich,

Candidate of physical and mathematical sciences, Leading scientist of the Main magnetic field laboratory, Pushkov Institute of Terrestrial magnetism, Ionosphere and Radio Waves Propagation of the Russian Academy of Sciences Харитонов Андрей Леонидович.

Кандидат физико-математических наук, ведущий научный сотрудник лаборатории главного магнитного поля, Институт земного магнетизма, ионосферы и распространения радиоволн им. Н.В. Пушкова РАН

Abstract. The purpose of this paper is to practically confirm the theoretical ideas of academician P.N. Kropotkin and prof. N.P. Kudryavtsev about the geological processes of formation of oil and gas fields. It was revealed that there is a certain spatial relationship in the location of oil and gas fields in the North Eurasia with the location of regional linear and circular morphological structures that are fixed on the earth's surface, according to the interpretation of satellite images of the earth's surface relief. The on-board spatial location of the main oil and gas fields relative to the central part of the Pre-paleozoic mantle plumes of the North Eurasia, forming circular morphological structures of the central type, was revealed.

Keywords: circular morphological features, Pre-paleozoic mantle plumes, oil and gas potential.

Аннотация. Цель данной статьи заключается в том, чтобы практически подтвердить теоретические представления академика Кропоткина П.Н. и профессора Кудрявцева Н.П. о геологических процессах образования месторождений нефти и газа. Было выявлено наличие определенной пространственной связи в расположении месторождений нефти и газа на территории Северной Евразии с расположением региональных линейных и кольцевых морфологических структур, фиксирующихся на поверхности Земли, по данным дешифрирования космических снимков рельефа поверхности Земли. Было выявлено бортовое пространственное расположение основных месторождений нефти и газа относительно центральной части допалеозойских мантийных плюмов Северной Евразии, образующих концентрические морфологические структуры центрального типа.

Ключевые слова: концентрические морфологические особенности, допалеозойские мантийные плюмы, потенциальная нефтегазоносность.

DOI 10.54092/25421085_2022_2_23

Рецензент: Сагитов Рамиль Фаргатович, кандидат технических наук, доцент, заместитель директора по научной работе в ООО «Научно-исследовательский и проектный институт экологических проблем», г. Оренбург

Введение

Некоторыми авторами выявлена корреляционная взаимосвязь расположения месторождений газообразных (газ), жидких (нефть) углеводородов и тектоно-кольцевых структур (ТКС) центрального типа – выходов на поверхность допалеозойских мантийных плюмов [1-3]. По данным дешифрирования космических снимков поверхности рельефа разных регионов Евразии различными авторами [1-6] было выявлено множество тектоно-кольцевых структур центрального типа разного типа и размера (от нескольких сотен метров до нескольких тысяч километров). Большинство этих тектоно-кольцевых структур центрального типа возникло в процессе геологической эволюции Земли. Тектоно-кольцевые структуры центрального типа Евразийского региона имеют различный возраст и различные виды физических механизмов их образования, определяющих их морфологические поверхностные и глубинные особенности и их пространственные размеры. Известно, что регионах Евразии имеется несколько различных физических механизмов образования тектоно-кольцевых структур магматический (плюмовый, магмато-вулканический, центрального типа: грязевулканический), метеоритный, дегазационно-взрывной, тектонический (цилиндрические метаморфический, сейсмический, комплексный [5]. Отмечают разные поверхностные морфологические особенности тектоно-кольцевых структур центрального типа: кольцевые валообразные, спиралевидные и конусообразные поверхностные структуры. Пространственные размеры выявленных разновозрастных тектоно-кольцевых структур центрального типа, наблюдаемые на территории Евразийского региона колеблются от нескольких сот метров до тысяч километров в диаметре. Примеры некоторых тектоно-кольцевых структур центрального типа, расположенных в пределах восточной части Евразийского региона, выявленных по комплексу геолого-геофизических данных показаны на рис. 1.

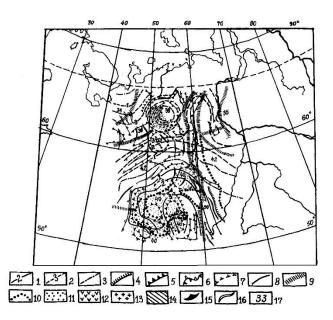


Рисунок 1. Комплексная геолого-геофизическая схема расположения некоторых морфоструктур центрального типа, тектонических нарушений и изолиний аномального магнитного и гравитационного полей в пределах западной части Северной Евразии. 1 изодинамы положительных значений аномального магнитного поля, 2 - изодинамы отрицательных значений аномального магнитного поля, 3 - изодинамы нулевых значений аномального магнитного поля, 4 - верхнекоровые тектонические разломы, 5 - уступы рельефа по данным космических фотоснимков, 6 - оси простирания мезозойских и палеозойских структур, 7 - концентрические и дуговые линеаменты, связанные с кольцевыми и дуговыми тектоническими разломами, 8 – линеаменты, 9 – краевые ограничения геоблоков с разным типом земной коры по геологогеофизическим данным, 10 - краевые ограничения геоблоков с разным типом земной коры по данным дешифрирования космических снимков, 11 - формационные комплексы слоев земной коры, 12 - области распространения орогенных гранитоидов, 13 – структурно-вещественные комплексы земной коры по геолого-геофизическим данным, 14 - структурно-вещественные комплексы земной коры по данным дешифрирования космических снимков, 15 - глубинные литосферные разломы, 16 складчатые структуры фундамента, 17 – значения мощности земной коры в километрах.

Используемые методы исследования

Для выявления тектоно-кольцевых структур центрального типа на территории Евразии, помимо геолого-геофизических данных, были использованы материалы дешифрирования космических снимков. Целым рядом авторов [5, 6] было отмечено, что с уменьшением разрешающей способности космических изображений, то есть генерализацией космических изображений, из них может быть извлечена структура земной коры все более глубоких ее горизонтов. Кроме того, было установлено, что

более надежная корреляционная связь проявляется между результатами космических изображений и геофизическими полями, а не с геологическими материалами, изображенными на региональных геологических картах.

Некоторые теоретические представления о тектоно-кольцевых структурах – поверхностных выходах мантийных плюмов

Большинство гигантских (тысячи километров в диаметре) тектоно-кольцевых структур центрального типа (нуклеаров) образовалась в результате возникновения мантийных плюмов и суперплюмов, внедрившихся в земную кору из мантии в определенный геохронологический период эволюции Земли. К тектоно-кольцевых структурам центрального типа первого порядка на территории Евразии можно отнести Балтийскую (3), Скифскую (7), Московскую (8), Прикаспийскую (9), Ноябрьскую (10) и другие (рис. 2). На Восточно-Европейской платформе (рис. 1) имеются и тектоно-кольцевые структуры центрального типа меньшего порядка, такие как Тимано-Печорская (39), Волго-Уральская (40) и некоторые другие, которые образуются в бортовых зонах тектоно-кольцевых структур центрального типа высшего порядка, таких как Ноябрьская (10), Прикаспийская (9) и некоторых других изображенных на рис. 2.

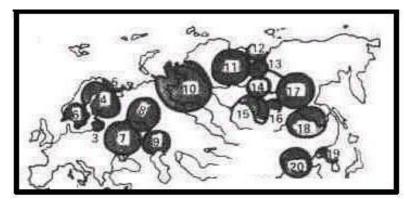


Рисунок 2. Основные тектоно-кольцевые структуры центрального типа 3-го и 4-го порядка, обусловленных палео мантийными плюмами [5]. В частности, на территории Евразии расположены крупные тектоно-кольцевые структуры центрального типа такие как: 3 – Балтийская, 4 – Фенно-Карельская, 5 – Свеко-Норвежская, 7 – Скифская, 8 – Московская, 9 – Прикаспийская, 10 – Ноябрьская, 11 – Хетта-Оленекская, 12 – Оленекская, 13 – Тунгусская, 14 – Вилюйская, 15 – Ангарская, 16 – Витимо-Олекминская, 17 – Алдано-Становая, 18 – Амурская, 19 – Сино-Корейская, 20 – Северо-Китайская.

В недрах Земли, в результате продвижения из мантии к поверхности Земли магматических образований термальных плюмов [4] образуется усеченная воронкообразная глубинная структура, по граничным зонам которой винтообразно продвигаются к поверхности газотермальные и гидротермальные потоки. Подобные структуры центрального типа, образованные допалеозойскими мантийными плюмами, были проанализированы в работе [4] рис. 3.

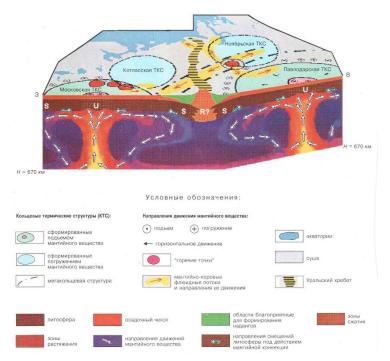


Рисунок 3. Схема глубинного строения Котласской, Ноябрьской, Московской, Павлодарской тектоно-кольцевых структур (ТКС), сформированных допалеозойскими мантийными плюмами [4].

Геолого-геофизическая интерпретация полученных данных

Наблюдаемые тектоно-кольцевые структуры ВЕП обусловлены в основном гранито-гнейсовыми образованиями фундамента. На северном обрамлении восточной Евразии, в районе о. Врангель отчетливо выделяется региональная тектоно-кольцевая Северо-Чукотская тектоно-кольцевая структура центрального типа 4-го порядка, осложняющая Беринговоморскую ТКС 2-го порядка. По результатам комплексных геолого-геофизических исследований были построены схематические глубинные разрезы земной коры, пересекающие Северо-Чукотскую ТКС (рис. 4).

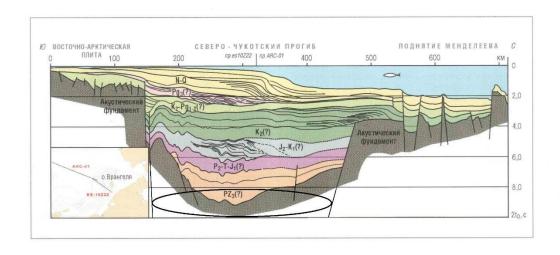


Рисунок 4. Геолого-геофизический разрез глубинного строения Северо-Чукотской тектоно-кольцевой структуры [7], сформированной одноименным Докембрийским мантийным плюмом.

Из построенного геолого-геофизического разреза, пересекающего Северо-Чукотскую тектоно-кольцевую структуру центрального типа (рис. 4) можно видеть, что глубокая Мохоровичича наблюдается (около 8 километров) на границе воронкообразная депрессия, являющаяся основанием этой ТКС в земной коре. воронкообразные наблюдаются Аналогичные депрессии на этом геологогеофизическом разрезе в значениях глубины залегания границы пермо-триасового (Р-Т-Ј) возраста, разделяющей породы осадочного чехла и породы палеозойского фундамента, а также наблюдается кольцевая депрессия в значениях уровня рельефа поверхности морского дна. Валообразная кольцевая структура, оконтуривающая на поверхности морского дна Северо-Чукотскую тектоно-кольцевую центрального типа вместе с аналогичными структурами в глубине земной коры позволяют наметить субвертикальные глубинные границы этой ТКС, немного наклоненные на север под небольшим углом к вертикали.

Тектоно-кольцевые структуры, такие как Северо-Чукотская (39) и некоторые другие, показанные на карте перспектив нефтегазоносности шельфовых зон Северной Евразии (рис. 5) образуют вокруг себя достаточно обширные перспективные и высокоперспективные зоны со значительными запасами углеводородов, сделанные на основании данных комиссии Организации Объединенных Наций. То есть, независимые оценки перспективности Арктических регионов Северной Евразии, сделанные по комплексу различных геолого-геофизических данных совпадают по месту расположения с перспективными зонами накопления углеводородов, выделенных по

морфоструктурным [6] данным.

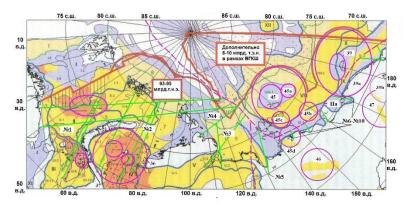


Рисунок 5. Карта перспектив нефтегазоносности осадочных бассейнов Арктических регионов Северной Евразии (с различными вариантами внешней границы континентального шельфа) [8]. Цветом обозначены площади с различной степенью перспективности концентрации углеводородов. Оранжевым цветом выделены высокоперспективные зоны, желтым цветом выделены умеренно перспективные зоны для поисков месторождений углеводородов. Зелеными прямыми линиями обозначены зоны региональных глубинных тектонических разломов Арктической зоны Северной Евразии (№1 – Кольские, № 2 - Обско-Ямалские, № 3 - Хатангские, № 4 – Таймырский, № 5 - Янский, № 6 - № 10 – Хромский, Индигирский, Колымский и др.). Зоны тектонокольцевых структур (обозначены лиловыми окружностями): (Южно-Карская - (36), Зыряновская - (46), Южно-Анадырская - (47), Восточно-Сибирская - (45, 45а, 45b, 45с, 45d), Северо-Чукотская - (39, 39а, 39b)), образованные одноименными мантийными плюмами. В квадратных рамках приведена предварительная оценка ресурсов углеводородов в пределах минимальной площади внешней границы континентального шельфа, принимаемой комиссией ООН по Морскому праву.

Выводы

По результатам применения данных дешифрирования космических снимков, использования данных аномального магнитного и гравитационного полей на территории Евразии выявлены основные тектоно-кольцевые структуры центрального типа, которые могут быть связаны с месторождениями углеводородов.

На территории восточной Евразии построены комплексные геофизические разрезы земной коры, которые подтверждают теоретическое глубинное строение некоторых тектоно-кольцевых структур центрального типа, образованных допалеозойскими мантийными плюмами.

References

- 1. Харитонов А.Л. Использование комплекса спутниковых и наземных магнитных измерений для геолого-геофизического изучения Арктического региона // В сборнике: Гелиогеофизические исследования в Арктике. Сборник трудов второй Всероссийской конференции. 2018. С. 98-101.
- 2. Харитонов А.Л. Комплексный геолого-геофизический анализ некоторых морфоструктур центрального типа и их связь с месторождениями нефти и газа // Вестник института геологии Коми научного центра Уральского отделения РАН. 2018. № 7(283). С. 3-9.
- 3. Харитонов А.Л. Изучение глубинной структуры мантийных суперплюмов каналов дегазации земных недр // International Journal of Professional Science. 2019. № 9. С. 16-30.
- 4. Горный В.И. и др. Модель мантийно-литосферного взаимодействия по данным комплексирования на геотраверсе Уралсейс сейсморазведки и дистанционного геотермического метода. В кн.: Глубинное строение и геодинамика Южного Урала. Тверь, 2001. С. 227-238.
- 5. Кац Я.Г., Полетаев А.И., Сулиди-Кондратьев Е.Д. Кольцевые структуры лика планеты. М.: Знание, К 62. 1989. 48 с.
- 6. Соловьев В.В. Структуры центрального типа территории СССР по данным геолого-геоморфологического анализа. Л.: Изд-во ВСЕГЕИ, 1978. 25 с.
- 7. Сенин Б.В., Леончик М.И. Стратегические направления развития минерально-сырьевой базы углеводородов нераспределенного фонда недр морских акваторий // Минеральные ресурсы России. Экономика и управление. 2016. № 6. С. 3-14.
- 8. Каминский В.Д. Глубинное строение Центрального Арктического бассейна // Автореферат на соискание ученой степени доктора геолого-минералогических наук. С-Петербург. 2009. 47 с.

TECHNOLOGY, ENGINEERING

UDC 004.67:621.3.049.77

Mozhzhukhina A. V. LSI element placement method based on deep reinforcement learning

Mozhzhukhina A. V.

National Research University of Electronic Technology, Moscow, Russia, SIC «Technological Center», Moscow, Russia

Abstract. In connection with the increasing complexity of large integrated circuits (LSI), the problem of improving computer-aided design systems (CAD) is acute. In particular, fast solutions are currently required at the stage of topological design of microcircuits, especially in domestic CAD systems. This article discusses the possibilities of using modern artificial intelligence capabilities in the field of microcircuit design. It substantiates the need to use and brief descriptions of some technologies and sections of artificial intelligence, such as deep reinforcement learning (DRL) in connection with the formalization of the task in the form of a Markov decision process, neural networks in connection with the representation of LSI in the form of a weighted graph with feature vectors. Additionally, an analysis of the most common architectures of neural networks is given. In addition, a method for placing LSI elements at the stage of topological design based on DRL using graph neural networks (GNN) is presented with a brief description of the stages: processing the initial LSI design and the characteristics of the elements to be placed and the basic matrix crystal (BMC), training or using an agent, asserting the placement and maintaining related information.

Keywords: LSI, topology, EDA-system, GNN, reinforcement learning, deep learning.

DOI 10.54092/25421085_2022_2_31

Рецензент: Сагитов Рамиль Фаргатович, кандидат технических наук, доцент, заместитель директора по научной работе в ООО «Научно-исследовательский и проектный институт экологических проблем», г. Оренбург

Introduction

More and more areas of science and industry are striving to introduce the achievements of the field of artificial intelligence into their processes. The field of electronics was no exception, where many processes are associated with automation [1, 2]. In particular, at present, a lot of research is being carried out on the introduction of artificial intelligence in the process of designing microcircuits [3-7].

Since the technological processes for the production of microcircuits are decreasing, and the number of elements is increasing, the development process becomes more complicated and more expensive. Previously, this was compensated by the use of CAD on

standard algorithms. However, in the current realities, standard algorithms, even when using parallelization, turn out to be too long and inefficient.

In the field of domestic production of LSI, an improvement in CAD using modern methods and tools is also required. One of the stages requiring changes is the stage of topological design, in particular, the operation of placing LSI elements on the BMC [8].

Purpose of the research

The most efficient, but the slowest and most costly, in finding a solution to the problem of placing LSI elements are greedy algorithms, which boil down to enumeration of all possible options. The main part of the standard algorithms used is their modification or parallelized version. With an increase in the number of elements in microcircuits, such algorithms become extremely inefficient.

Thus, new modern methods and means are needed. Taking into account the achievements in the field of artificial intelligence [9, 10] and the first studies on its application in the field of electronics, it was decided to analyze the possibility of using them for the problem of placing LSI elements.

Materials and Methods

For the correct selection of methods and means for solving the problem of placing LSI elements, it is necessary to formalize it.

Used sets:

- 1. $E = \{e_1, e_2, ..., e_n ..., e_N\}$ set of elements of the microcircuit for placement;
- 2. $P = \{p_1, p_2, ..., p_m, ..., p_M\}$ a fixed set of positions in which elements from the set E must be placed.

The main condition in this case:

$$\sum_{n=1}^{N} S_{\varepsilon_n} \leq \sum_{m=1}^{M} S_{p_m}.$$

Minimum required metrics for evaluating the final placement of LSI elements:

- 1. estimation of the total distance between connected elements;
- 2. calculation of delays with a margin to assess the progress of the signal while maintaining the requirements for the microcircuit;
- 3. assessment of the microcircuit filling density with elements in order to avoid excessive concentration of elements at a specific point on BMC.

In the general case, the placement problem is reduced to a Markov decision-making process [11]. It can be solved by using reinforcement learning to approximate the optimal policy through learning reward maximization. To work with a complex structure - a LSI project, neural networks will be required [12].

Some of the most common neural network architectures are: Fully Connected Neural Network (FCNN), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN), and Graph Neural Network (GNN). They can work with all possible representations of information, however, the problem is how well they are able to hold a representation of the relationship of information elements to each other. The following are brief characteristics and most common uses of these neural network architectures.

FCNN. Used for a variety of types of information from simple numbers to images and sounds. However, to keep the structure, i.e. "Remember" about the connection of the elements at the input to each other, can not in principle. In addition, this neural network is capable of receiving only the initially specified size of information.

CNN. Mainly used for image processing. Cannot hold structure and is unable to accept information of different sizes.

RNN. Most often used in the processing of textual information. Can hold simple links between pieces of information for a short time. The size of the information may vary. However, the longer the information supplied to the input, the worse the relationship between the first and the last units of information is retained in the network memory.

GNN. Works with graphs that can represent different types of coded information. In addition, this network holds the structure of the graph and can accept graphs of different sizes, provided that the characteristics of the vertices and connections are the same.

Thus, a GNN was chosen.

Formalization of the problem using Markov decision processes is as follows [13-15]:

$$J(\theta,G\{E\to P\}) = \mathbb{E}_{\pi_\theta}\big[R_{p,G}\big] = \sum_p \pi_\theta(p|G)\,q_{p,G},$$

where θ are the weights of the approximating function, i.e. neural network, π_{θ} is the agent's policy, G is a graph representing the placement of elements of the set E in the cells of the set P, $R_{p,G}$ is the reward, $q_{p,G}$ is the value function.

The neural network will be used to evaluate placement. To do this, it is required to present the LSI graph in a special way (fig. 1) - to select the necessary characteristics that are important for evaluation.

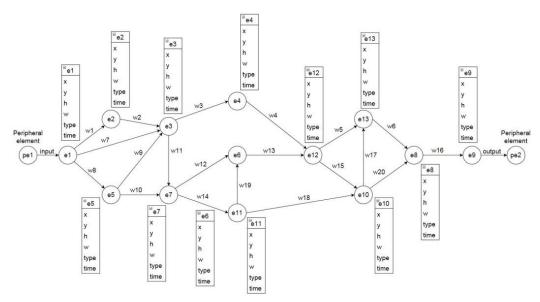


Fig.1. Representation of a part of the LSI in the form of a graph structure with vectors of characteristics of nodes and weights of connections

Results

The placement of LSI elements according to the developed method is carried out in stages (Fig. 2). Before the start of placement, preparatory work is carried out: the collection of information about the LSI, the connections of the elements, the peripheral elements and their placement, the design and area of the BMC.

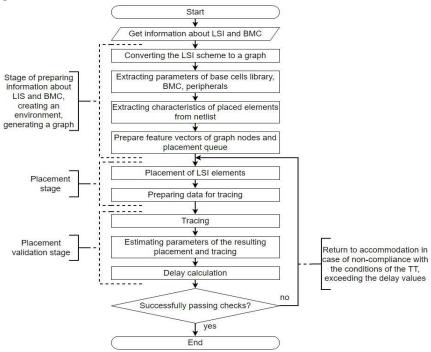


Fig.2. LSI Element Placement Method Using Reinforcement Deep Learning Agent

At the first stage, the received information is converted into working data structures, including information about the connections of elements is converted into a matrix form, the necessary variables, the agent and the neural network are initialized, and the queue of placed elements is formed.

The next step is directly step-by-step placement of LSI elements. At this moment, the agent gets access to the queue of elements to be placed, the graph structure and the representation of the BMC. The placement takes place in several steps, repeating in a circle one after another until the queue of elements for placement is empty. The first step is to prepare a package from several placements, one element at a time, and calculate the agent's goal. The second step calculates the estimate of the neural network of the current placement, obtained on the basis of a graph structure that changes over time from the placement of LSI elements on the BMC, checking some metrics that can be checked throughout the process, and calculating rewards.

At the placement approval stage, the placement is evaluated according to basic metrics, then, if the placement is found to be satisfactory, it is submitted for tracing. The average metrics from the database for similar chips will be used to evaluate the final placement. After the trace, the usual general checks will be performed, including the calculation of delays. If all tests are passed, then placement is considered successful. In case of problems, return to the previous steps.

During the training, the methodology will additionally introduce the stage of documentation, i.e. saving the learning history of the neural network weights, their changes and agent parameters to the database, reports on placement, queues and changes in the LSI graph structure, calculations of evaluation metrics and awards, both at the end and during the entire placement.

Discussion

This method of placing elements is designed to reduce the time of the physical stage of LSI design. Based on the results of scientific research related to the implementation of artificial intelligence in related fields, as well as the analysis of various methods and tools, the use of deep reinforcement learning will lead to significant improvements.

The main direction of future research will be related to the development of a test module for implementation in the microcircuits development process of CAD "Kovcheg" for testing and comparing results with existing methods for placing LSI elements.

References

- 1. Гагарина Л.Г., Колдаев В.Д. Алгоритмы и структуры данных. М.: Финансы и статистика, 2009. 482 с.
- 2. Макушин М.В., Фомина А.В. Искусственный интеллект и рентабельность как движущие факторы развития САПР // Электроника: наука, технология, бизнес. №4 (185) С. 90–100.
- 3. Иванова Е. Synopsys: тренды, решения, мифы // Электроника: наука, технология, бизнес. №7 (188). С. 16–21.
- 4. Абасов, Р. К., Силла А. Анализ методов искусственного интеллекта САПР технологических процессов производства электронной аппаратуры. // Молодой ученый. № 24 (128). С. 41–48.
- 5. Познер М. «Переплетение» трендов создает фантастические возможности для микроэлектроники // Электроника: наука, технология, бизнес. №10 (181). С. 12–16.
- 6. G. Lu, S. Areibi An island-based GA implementation for VLSI standard-cell placement // Genetic and Evolutionary Computation Conference. Seattle, WA, USA, Proceedings, Part II, Июнь 26-30, 2004. C. 1138–1150.
- 7. Goldie A., Mirhoseini A. Placement Optimization with Deep Reinforcement Learning. // Proceedings of the International Symposium on Physical Design, 2020. C. 2–7.
- 8. Гаврилов С.В., Денисов А.Н., Коняхин В.В. [под ред. Чаплыгина Ю.А.] Система автоматизированного проектирования «Ковчег 2.1». М.: Микрон-Принт, 2001. 210 с.
- 9. Дейтел П., Дейтел Х. Python. Искусственный интеллект, большие данные и облачные вычисления. СПб.: Питер. 2020. 864 с.
- 10. Эндрю Гласснер. Глубокое обучение без математики. Том 2. Практика. М.: ДМК Пресс, 2020. 610 с.
- 11. Richard S. Sutton, Andrew G. Barto. Reinforcement Learning. An Introduction. Second edition. The MIT Press, Cambridge, Massachusetts, London, England, 2020. 548 c.
- 12. Yao Ma, Jiliang Tang. Deep learning on Graphs. Cambridge University press, 2021. 339 c.
- 13. Судхарсан Равичандиран Глубокое обучение с подкреплением на Python. OpenAl Gym и TensorFlow для профи. СПб.: Питер. 2020. 320 с.
- 14. Лапань М. Глубокое обучение с подкреплением. AlphaGo и другие технологии. СПб.: Питер. 2020. 496 с.
- 15. Miguel Morales. Grokking Deep Reinforcement Learning. MANNING, Shelter Island, 2020. 472 c.

Electronic scientific editions

International journal of Professional Science

international scientific journal №2/2022

Please address for questions and comments for publication as well as suggestions for cooperation to e-mail address mail@scipro.ru



Format 60x84/16. Conventional printed sheets 1,8
Circulation 100 copies
Scientific public organization
"Professional science"