Journal of Siberian Federal University. Humanities & Social Sciences 6 (2019 12) 1072–1087
~ ~ ~

УДК 37.02

# Multidimensional Algorithmic Thinking Development on Mental Learning Platform

**Nikolay I. Pak[a, b], Tatiana A. Stepanova[a],**
**Irina V. Bazhenova[b]* and Irina V. Gavrilova[a]**
*[a]Krasnoyarsk State Pedagogical University*
*named after V.P. Astafyev*
*89 Ada Lebedeva Str., Krasnoyarsk, 660049, Russia*
*[b]Siberian Federal University*
*79 Svobodny, Krasnoyarsk, 660041, Russia*

Received 08.11.2018, received in revised form 25.02.2019, accepted 15.04.2019

*The problem of algorithmic thinking development in computer science, computer technology and information technology courses remains relevant despite a lot of research done in the area. The present article is intended to substantiate the mental learning platform for further use of cognitive methods and training tools; it discloses the essence of multidimensional algorithmic thinking and presents mental and embodied (kinaesthetic) programming training tools. The authors arrive at the conclusion that development of multidimensional algorithmic thinking should be carried out through the use of mental algorithmic maps for different styles of thinking, mental and empirical tasks, as well as kinaesthetic simulators. Such training tools involve all channels of perception and greatly contribute to the understanding and better assimilation of "Algorithmization and programming" subject. The results of the research can be useful for computer science teachers at schools and programming teachers at higher educational institutions.*

*Keywords: Mental learning platform, multidimensional algorithmic thinking, mental algorithmic maps, embodied approach.*

*Research area: pedagogy.*

Citation: Pak, N.I., Stepanova, T.A., Bazhenova, I.V., Gavrilova, I.V. (2019). Multidimensional algorithmic thinking development on mental learning platform. J. Sib. Fed. Univ. Humanit. soc. sci., 12(6), 1072–1087. DOI: 10.17516/1997–1370–0410.

Modern education standards applicable to both higher and secondary education imply the shift of learning priorities towards the development of personal features of the learners. In this regard, the main purpose of computer science, computer engineering


* Corresponding author E-mail address: iv.bagenova@yandex.ru

and information technology courses is the development of algorithmic thinking of the students.

In order to meet these requirements, it is reasonable to design a new cognitive learning platform designed for efficient development of the cognitive skills of the learners (Nigmatulina, Pak, 2017). In this context, the term "learning platform" means a structural and conceptual methodological ground for the development of teaching method systems.

Using the results of human brain cognitive capacity modelling and cognitive teaching technologies (series of methods, techniques and tools, designed with respect to the individual mental properties of the learners), it is possible to ensure the efficient understanding of academic information and intellectual development of the learners.

Thinking is one of the brain functions, a continuous natural information process. The thinking mechanism is based on mental patterns of the senses recorded in the memory and meta-senses of the environment in time and space, enriched with the model and conceptual categories (Neisser, 1976; Pak, 2012).

A great role in thinking is played by the mental algorithmic patterns. Any professional or any other everyday human activity requires modelling, accumulation and analysis of information followed by the development of an action algorithm. One's individual capacity of such algorithm development and application forms the foundation for algorithmic thinking.

The objective of the present research is to substantiate the cognitive learning platform for implementation of the innovative teaching models through the specification of the multidimensional algorithmic thinking concept and determination of its development routes.

Algorithmic thinking development begins at the age of 5–6 and continues through the school age, mostly at the courses of computer science, natural science and STEM disciplines. To a great extent, algorithmic thinking is developed at computer science classes.

After that, through the Programming Languages and Methods course at the higher educational institution, students develop a special algorithmic style of thinking required for the adoption of programming languages of various paradigms, such as imperative, declarative (object-oriented, functional, logical) and the script programming paradigm that emerged together with Web programming.

At the same time, there appeared a new branch in programmer training: parallel computing, parallel information processing and parallel programming. The

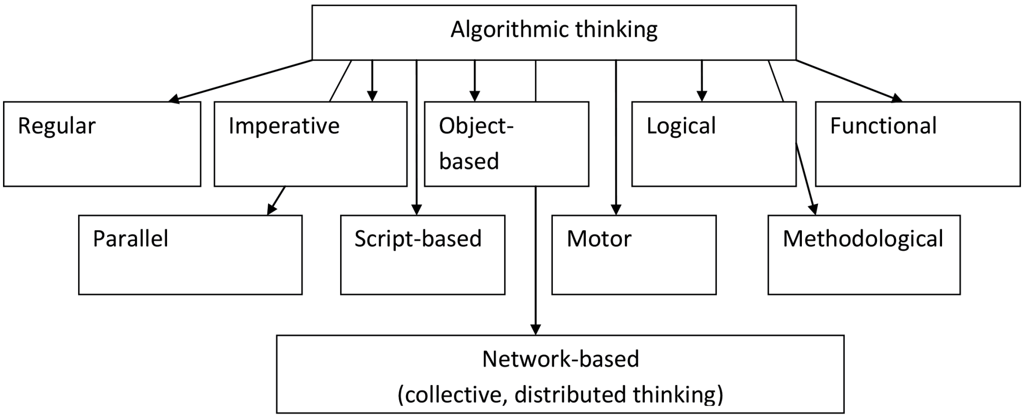



Fig. 1. Multidimensional structure of algorithmic thinking

acquisition of programming languages from different paradigms evokes a number of challenges due to the readjustment of thinking and switching of the structure and type of the algorithms designed for the solution of the set tasks. The studies of different programming paradigms are intended to form a diversity of thinking styles, including object-based, functional, logical, script-based and parallel ones (Gazeykina).

Each paradigm and technology of programming corresponds to its *dimension* of algorithmic thinking: imperative object-based, logical functional and parallel ones (Fig. 1).

The style of algorithmic thinking specific for a certain programming paradigm is one of its dimensions.

Shaping and development of various thinking styles firstly rest with the computer science and information technology teachers. In this regard, they bear a great responsibility for the right choice and implementation of the appropriate teaching methods. For bachelors, future computer science teachers, it is essential to develop algorithmic thinking in the methodological aspect. A modern computer science teacher needs to achieve a sufficient level of multidimensional algorithmic thinking and to be trained in the development of the algorithmic thinking of the learners (Stepanova, 2014).

Let us consider a basic, but unfairly underestimated aspect, which is the motor algorithmic thinking that controls the motor activity of the person. Undoubtedly, it is formed on the basis of mental motor patterns (Stepanova, 2014). The purposeful moves the body does are based on the algorithms stored in the motor memory. It means that it is the motor algorithmic thinking, shaped and developed from the moment of birth, that is in charge of the generation, accumulation and activation of such algorithms. The diversity of one's mental motor patterns depends on the individual's engagement with sports, dance, singing, physical or technical activities etc. (Fomin, Vavilov, 1991)

The next factor of algorithmic thinking multidimensionality is determined by the network-based, distributed nature of the learning process, as that of Mega-Classes in computer science based on the methodology described in the works by N.I. Pak, M.A. Sokol'skaia, L.M. Ivkina (Akkasynova et al., 2017; Pak, Sokol'skaia, 2017; Pak et al., 2017).

During the Mega-Class, the problem solution algorithm is developed by several geographically separate work groups communicating through computer network. The problem solution process is distributed between the learning parties working in parallels and becomes multidimensional. Basically, it is intended to reproduce the pattern of project development by a team of programmers or serious problem solution by a group of scientists. In this regard, it should be described as a process of multidimensional collective thinking, a collective mind. It is not just a sum of the knowledge of all participants of the joint thinking process; it is generation of some new collective knowledge through the new collective network-based algorithmic style of thinking, which becomes possible in teamwork only, capable of handling the most complex tasks and problems.

The network thinking style peculiarities depend on the specificity of distribution of the problem solving process (Fig. 2).

In this regard, it makes sense to introduce another algorithmic thinking dimension, network-based thinking, shaped and developed in the process of distributed network projects similar to the Mega-Class.

The selection of optimal conditions for the successful shaping and development of algorithmic thinking should begin with the studies of thinking and perception processes. Despite a number of researches in the field of cognitive psychology, algorithmic thinking theory has not been properly formulated yet.

Thinking studies can be approached in different ways. There are psychological, physiological and cybernetic algorithmic thinking theories.

The schemata theory of U. Neisser (Neisser, 1976) appears to be the most acceptable for thinking mechanism modelling. Our spatial and temporal orientation and action skills prove that our memory develops and stores the spatial, temporal and action schemata. The attempts of formalizing the thinking processes from this point of view formed the "mental map" term as a mental schema model.

Contemporary physiological thinking theories define consciousness as a brain tool; they identify its biological functions, providing an opportunity of the objective research

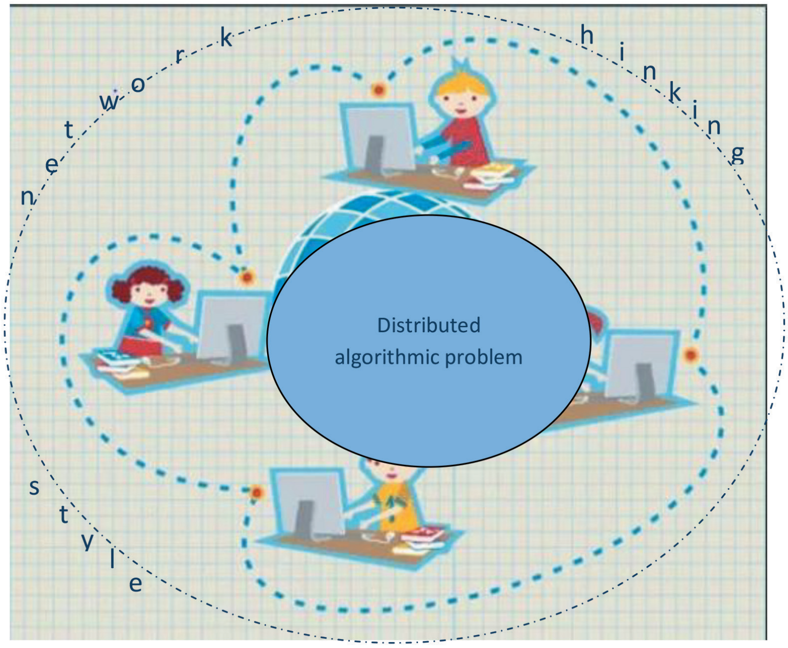



Fig. 2. Network cooperation for common problem resolution

methods, reveal its nervous and cellular structure (Kogan, 1988; Wilson, Golonka, 2013). For instance, cog theory identifies the biological and mental schemata at the brain cell level. According to the theory, cogs are the systems of neurons retaining certain spatial, temporal or action images (Anokhin).

Along with dealing with the artificial intelligence creation issues, formulation and automation of the thinking processes, cybernetics come up with the three basic knowledge presentation models: semantic networks, frames, and logics (Gavrilova, Khoroshevskiy, 2000; Poole, Mackworth, Goebel, 1998).

The researchers dealing with artificial intelligence issues remark that a semantic network is a model that corresponds to the contemporary idea of the long-term human memory most of all (Russell, Stewart, Norvig, 2015). However, the majority of the artificial intelligence systems are based on frames and predicate logic for greater formalization and efficient computer implementation.

As a rule, the works dedicated to the use of mental maps in academic processes, are presented as a simple semantic network or a semantic graph, with the concepts designated as hubs with certain relations between them (Bogdanova; Sidorov). To transform a semantic graph into a semantic network, it is necessary to indicate the types of such relations. If some objects are presented in the network hubs as input data and target objects, the relations between them indicate the possible routes of achieving the target in the presence of these or those input objects; then, a semantic network turns into a mental map as a model of mental schemata (Bazhenova, Babich, Pak, 2016).

Therefore, one may suggest that due to the contemporary psychological and biological thinking theories, classic knowledge presentation models can be supplemented with the mental model based on mental schemata and maps building.

It should be noted, however, that action mental schemata present mental algorithmic structures.

Unlike the classic formalization process of an algorithm recorded in a natural language or with a flowchart, an algorithmic mental map is modelled through a graph structure (Bazhenova, Stepanova, 2013).

As an example, let us study a mental algorithmic problem solution map with the use of a conditional operator (Fig. 3). The problem is to determine whether a triangle is right-angled or not based on the entered lengths of its three sides.

The mental map visualizes the problem solution algorithm from the problem condition analysis to the code writing stage. To enhance the sense perception and associative thinking, graphic images of triangles and colouring are used: the input data and main problem solving steps are highlighted in blue, possible challenges are highlighted in red, and applicable solutions are highlighted in green. As the mental map is an algorithm, the solution sequence is set by means of numbers (circled figures). If the mental map is regarded as a decision tree, the solution may be achieved by following the numerated tree leaves clockwise.

From the authors' experience of working with students, it may be concluded that assisted mental algorithmic map building is very useful for the development of the students' algorithmic thinking and efficient studies of algorithmic structures and programming languages. Mental algorithmic maps activate the sensual memory, visualize the problem-solving thinking processes and the individual thinking process of a certain person.

The mental and empirical tasks provide a huge didactic potential for the development of algorithmic thinking in the school computer science course, at the initial stage of learning of the basic algorithmic structures. The solution of such problem consists of three parts and relies on the following terms: life situation, mental map, and flowchart, activating the sensual, conceptual and model areas of thinking and memory. On the basis of a visualized life situation, the students identify the cognitive problem, make up a solution process and develop an algorithm flowchart. This algorithmic structure studying method is efficient due to its reliance

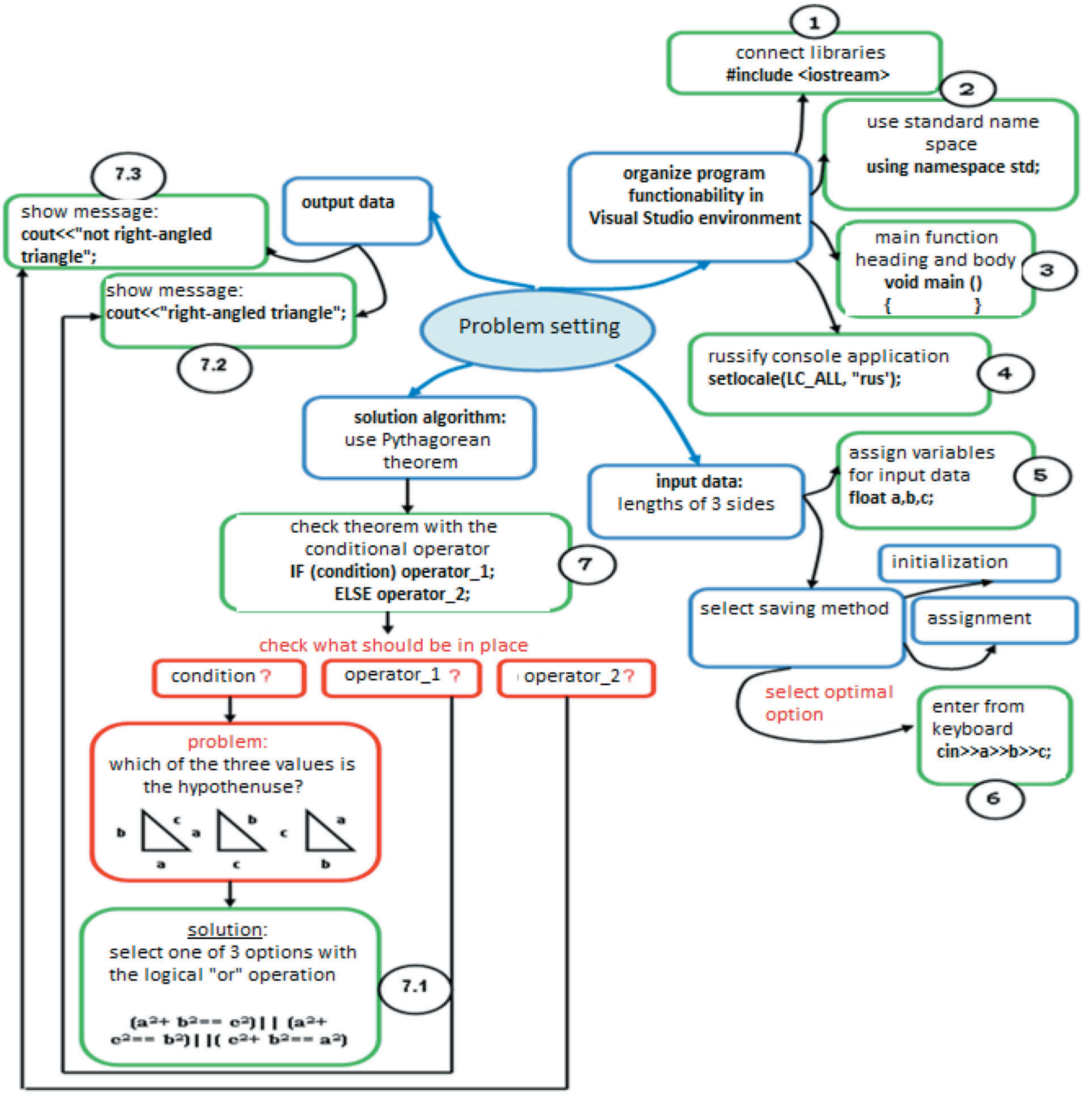
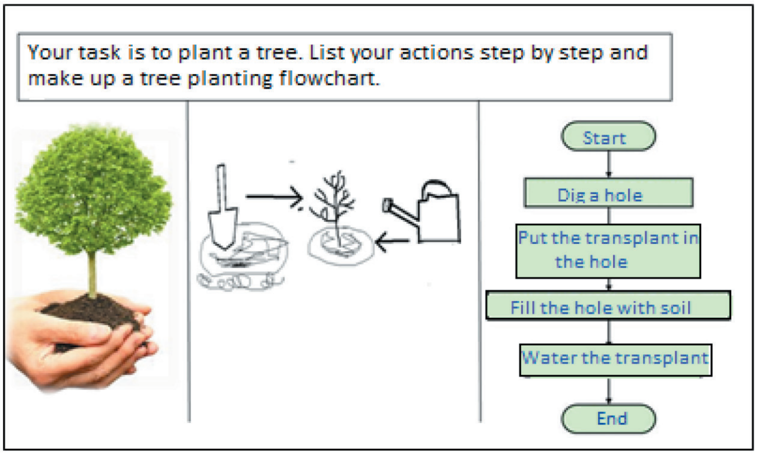


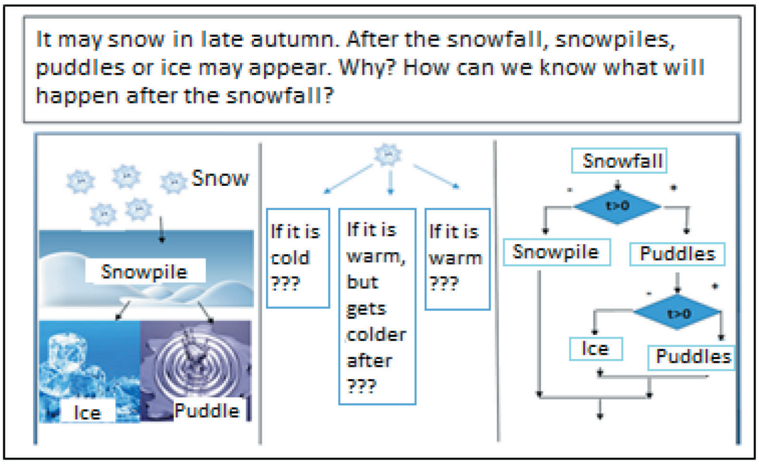

Fig. 3. Mental map example

upon various areas of memory: sensual, modelling, conceptual and abstract. Quite challenging for school students, the abstract flowchart development process is simplified through its connection to the two previous components: the life situation and the solution model presented as a mental map. Fig. 4 provides examples of three tasks presenting various types of algorithms. The central and right sides of the cards are to be filled in by the students.

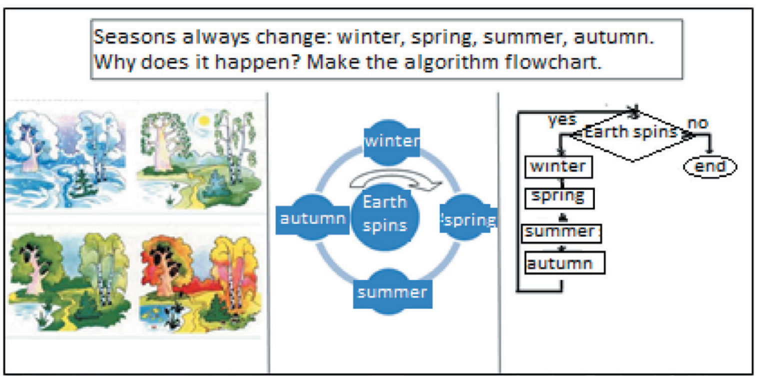
At first, the problem is solved in cooperation with the teacher: the teacher fills in the card, explaining the process, and demonstrates the three stages of the solution. Then the students complete the task on their own, working in pairs or in small groups, developing algorithms related to some life situations.




Example 1. Linear algorithm




Example 2. Fork algorithm




Example 3. Cyclic algorithm

Fig. 4. Mental and empirical problem examples

The suggested method has been tested and proven efficient; solving the mental and empirical tasks, the students succeeded to construct algorithms of different types. The non-standard information presentation and relation to the empirical experience of the students increased their motivation and improved their learning efficiency, which is proven by tests results.

The described technique improves understanding of the material and development of algorithm-making skill, as it is based on the peculiarity of the thinking process and thinking operations as such. The interim stage between problem setting and the algorithm flowchart development activates the conceptual area, relying upon the sensual and image memory, facilitating new knowledge acquisition. The card filling process completely conforms to the procedural structure of the algorithm making operations, based on the interconnection of the algorithm-making stages and the thinking processes involved.

The technique under consideration relevantly enhances understanding and acquisition of the algorithmization and programming knowledge, facilitates the development of algorithmic thinking.

The existing methods of algorithmic thinking development including the studied mental approach are not enough for the free shifting from the ordinary, everyday algorithmic thinking to the abstract flowcharts and program codes. They are intended to help visual and auditory learners along with the traditional teaching aids and methods. However, kinaesthetic perception organs are not engaged, though, according to the well-known statistics, kinaesthetic perception dominates for approximately 40 % of people. Kinaesthetic learners perceive the major part of information through senses: smell, touch, associations with the performed actions. They translate all perception of the surrounding world into the language of physical feelings, taste, smell and touch, using the bodily associations and motor memories as the main tool of information processing (Ashman, Conway, 2014).

In this regard, it appears necessary to create new means of algorithmic thinking development oriented on the kinaesthetic perception channels and motor memory activation. It is relevant not only for kinaesthetic, but also for visual and auditory learners. Firstly, the classification of people by perception type is conventional; pure types are scarce, and mixed types are more common. Secondly, activation of all perception channels in the learning process significantly increases the level of understanding (Schreiner, Lyddon, 2002).

Let us consider the embodied approach, unfairly underestimated by Russian researchers, which can make a considerable difference in algorithmic thinking development.

Embodied approach in thinking theory began its active development in the western cognitive science around the early 1990-s. English collocation “embodied cognition approach” would be translated into Russian with more precision with an emphasis of “embodiment” of the cognition process, physical embodiment of any subject engaged in cognition. This remark should be made when the collocation is translated briefly, but not accurately enough (Aliushin, Kniazeva, 2009).

The emergence and rapid development of the embodied approach was caused by the discontent of researchers with the computational approach to explanation of the cognition abilities of human and animals, dominating in the 1960-s.

Computational approach was opposed to the theoretical concept based on the following provisions: first of all, thinking is physical, and the nature of human thinking cannot be studied in isolation from the organism as a whole, as thinking is determined by peculiarities of perception, organs of senses, and, to a certain extent, occurs at the sensual level; secondly, human thinking is exposed to the external, natural environment and the sociocultural background; thirdly, cognitive abilities of a person are developed in action and through action. Action makes a decisive impact on the development of a certain style of thinking (Solso, 2006).

Today, many researchers and scientists working within the framework of the embodied approach tend to emphasize the complicated interaction between body and mind, between the person and the world he belongs to, instead of limiting human body to the input-output functions and explaining cognition from the point of view of mental symbols manipulations (Shapiro, 2006).

The main suggestion states that cognition is a complex and multidimensional process which stretches far beyond the limits of mind, where special tools, including the body, can be used in order to solve the problems and tasks faced by the person. As a rule, the majority of embodied cognition researchers discuss the cognition and general action issues from the philosophic point of view, but such results are of greatest interest for teachers and pedagogical studies (Rambusch, Ziemke, 2005).

Stepanov M.A. remarks that embodied approach opens a new perspective in the thinking theory development, as embodied cognition requires a movement capacity (Stepanov, 2011).

The main postulates of the embodied approach theory provide theoretical basis for the need for teaching aids that consider the interconnection between the bodily, kinaesthetic sensations, perception and thinking development process (Stepanova, 2014).

Fig. 5. Example of a kinaesthetic training set

Such aids are intended to ensure direct studies of a concept or a method through kinaesthetic and visual perception channels through visualization of the algorithm, step-by-step method analysis or vivid illustration of concepts. A distinctive feature of such teaching aids would be cognition through action. In computer science, those may be construction blocks, kinaesthetic (physical) training devices (Fig. 5), robotics etc. (Barkhatova, Nigmatulina, Stepanova, 2017).

For example, an array sorting algorithm may be studied with a kinaesthetic training set consisting of billiard balls arranged on a block.

Each ball representing an element of the array has a number, an array element index; the number can be erased and written again, as in the algorithm study process the elements change their places. Let us take N balls of different weight. The task is to arrange the balls in the descending order of their weight. To enhance the visual associations, the array balls may be coloured in such a way that in the correct order they form a familiar sequence, such as rainbow. It is easy to imagine the array sorting imitation with the bubble sort method.

This model implementation practice shows that after the manual sorting experience the code of the program based on the algorithm is clear to almost all students.

A similar set can be used for visualization of more complex sort algorithms, such as quicksort, radix sort that often remain unclear after traditional explanation even to the brightest students.

Traditional subject learning platforms are of knowledge nature, determining the cognitive abilities development mechanisms by creating a methodological system for training in each subject of the curriculum. Cognitive learning platform ensures the development of cognitive abilities of a student through the conceptual potential of a discipline by means of implementation of the mental and embodied teaching methods.

The algorithmic maps, mental-empirical problems and kinaesthetic training sets development and implementation experience proves that they are capable of activating cognitive activity of the trainees, developing their algorithmic thinking and increasing the efficiency of programming studies.

## References

Ashman, A., Conway, R. (2014). *An Introduction to Cognitive Education: Theory and Applications*. Routledge, 268 p.

Aliushin, A.L., Kniazeva, E.N. (2009). Telesnyy podkhod v kognitivnoy nauke [Embodied approach in cognitive science]. In *Filosofskie nauki* [*Philosophical Sciences*], 2, 106–125.

Andreeva, N.M, Artiukhov, I.P., Miagkova, E.G., Pak, N.I., Akkasynova, Zh.K. (2018). Organizing Blended Learning for Students on the Basis of Learning Roadmaps. In: *Journal of Social Studies Education Research (JSSER),* 9(2), 47–64.

Akkassynova, Zh., Pak, N., Ivkina, L., Romanov, D. and Khegay, L. (2017). Organization of Teaching Schoolchildren Programming in the Context of International Educational Cluster. In: *Man In India*, 97 (21), 595–608.

Anokhin, K.V. *Vnutri Vavilonskoy biblioteki mozga* [*Inside the Babylonian library of the brain*], available at: https://scisne.net/a-1589

Bazhenova, I.V., Babich, N., Pak, N.I. (2016). *Ot proektivno-rekursivnoy tekhnologii obucheniia k mental'noy didaktike* [*From projective and recursive technology of training to mental didactics*]. Krasnoyarsk, Siberian Federal University, 160 p.

Bazhenova, I.V., Stepanova, T.A. (2013) Ispol'zovanie metodiki mental'nykh kart pri obuchenii programmirovaniiu v vysshey shkole [Use of Mind Map Techniques for Teaching Programming and Higher Educational Institutions]. In: *Materialy II Vserossiyskoy konferentsii s mezhdunarodnym uchastiem "Perspektivy i vyzovy informatsionnogo obshchestva"* [*Proceedings of the 2nd All-Russian Scientific-Practical Conference with International Participation "Prospects and Challenges of Information Society"*], 173–176.

Barkhatova, D., Nigmatulina, E., Stepanova, T. (2017). Social Informatics: Natural Tools for Students' Information Training in the Conditions of Embodied and Mental Approaches Being Employed. In: *Journal of Social Studies Education Research*, 8(2), 100–116.

Barkhatova, D., Nigmatulina, E., Stepanova, T. (2017). *Naturnye sredstva obucheniia informatike v usloviiakh realizatsii telesno-mental'nogo podkhoda*

[Embodied Tools of Computer Science Teaching for Implementation of the Embodied and Mental Approach]. In: *Otkrytoe obrazovanie* [*Open Education*], 21 (4), 73–83.

Bogdanova, G.N. *Intellekt-karty kak sredstvo razvitiia intellektual'nykh sposobnostey uchashchikhsia* [*Mind maps as a Tool for Intellectual Development of Students*], available at: http://do.gendocs.ru/docs

Cartelli, A. (2009). Between Tradition and Innovation in ICT and Teaching. In: *Encyclopaedia of Distance Learning*, Hershey-New York, Information Science Reference, 187–193.

Gavrilova, I.V. (2018). Razvitie algoritmicheskogo myshleniia uchashchikhsia na osnove mental'no-empiricheskikh trit-zadach [Algorithmic Thinking Development Through Mental and Empirical *Trit*-Tasks]. In: *Informatika v obrazovanii* [*Informatics in Education*], 4, 50–55.

Gavrilova, T.A., Khoroshevskiy, V.F. (2000). *Bazy znaniy intellektual'nykh system* [*Knowledge Bases of Intellectual Systems*]. Saint Petersburg, Peter, 410 p.

Gazeykina, A.I. *Stili myshleniia i obuchenie programmirovaniiu studentov pedagogicheskikh vuzov* [*Thinking Styles and Programming Training of Pedagogical University Students*], available at: http://ito.edu.ru/2006/Moscow/I.html

Kogan, A.B. (1988). Neyrofiziologicheskie mekhanizmy myshleniia cheloveka [Neurophysiologic Mechanisms of Human Thinking]. In: *Osnovy fiziologii vysshey nervnoy deiatel'nosti* [*Basic Physiology of Higher Nervous Activity*]. Moscow, Vysshaiia shkola, 368 p.

Kirko, V.I., Malakhova, E.V., Pack N.I. (2014). Education for the future: new strategies of distance education for the universities of Eastern Siberia. In: *Turkish online journal of distance education*, 15(4), 23–33.

Neisser, U. (1976). *Cognition and Reality: Principles and Implications of Cognitive Psychology*, WH Freeman, 232 p.

Nigmatulina, E.A., Pak, N.I. (2017). Student-tsentrirovannoe obuchenie programmirovaniiu v pedagogicheskom vuze [Student-Centred Programming Teaching at Pedagogical University]. In: *Informatics and Education*, 2(281), 8–14.

Nikolaeva, U.S, Pak, N.I. (2017). Newest Web-Technologies for Studying and Diagnosing Individual Abilities of Learners. In: *Journal of Social Studies Education Research*, 8(2).

Ousterhout, John K. Scripting: Higher Level Programming for the 21st Century, available at: http://www.osp.ru/os/1998/03/179470

Pak, N.I., Sokol'skaiia, M.A. (2017). Edinaia metodicheskaia sistema obucheniia shkol'nikov i studentov na baze tekhnologicheskoy platformy "Mega-klass" [Unified

Methodological System of Subject Teaching on the Basis of Mega-Class Technological Platform]. In: *Prepodavatel' XXI veka* [*Teacher of the 21st century*], 1(1), 123–134.

Pak, N., Romanov, D., Khegay, L., Ivkina, L., Akkassynova, Zh. (2017). Model' mezhdunarodnogo Megauroka po izucheniiu programmirovaniia v shkolakh Rossii i Kazakhstana [Model of the International Mega-Class in Programming at Schools of Russia and Kazakhstan]. In: *Obrazovanie v Nizhnem Novgorode* [*Education in Nizhny Novgorod*], 1, 37–44.

Pak, N.I., (2012). Prostranstvenno-vremennaia model' pamiati [Spatial and Temporal Memory Model]. In: *Materialy II Mezhdunarodnoy nauchno-prakticheskoy konferentsii "Fundamental'nye nauki i obrazovanie"* [*Proceedings of the 2nd International Scientific-Practical Conference "Fundamental Science and Education"*], Biysk.

Pak, N.I., Petrova, I.A., Pushkareva, T.P., Khegay, L.B. (2018). Organization of Student-Centred Learning for Students on the Basis of Transformable Academic Course. In: *Astra Salvensis*, 6, 881–890.

Pak, N.I., Grinberg, G.M., Doroshenko, E.G., Lukyanenko, M.V., Savelyeva, M.V. (2017). The Model of Student-Centred Training for Master Students at Technical University. In: *Issue*, 16, 27–40.

Poole, D., Mackworth, A., Goebel, R. (1998). *Computational Intelligence: a Logical Approach*, New York, Oxford University Press.

Rambusch, J., Ziemke, T. (2005). The Role of Embodiment in Situated Learning. In Bruno Bara, Lawrence Barsalou, and Monica Bucciarelli (eds.). In: *Proceedings of the 27th Annual Meeting of the Cognitive Science Society*, Mahwah, NJ Lawrence Erlbaum, available at http://csjarchive.cogsci.rpi.edu/proceedings/2005/docs/p1803.pdf

Romero, P., Boulay, B.D., Robertson, J., Good, J., Howland, K. (2009). Is Embodied Interaction Beneficial When Learning Programming? In: Shumaker R. (eds.). *Virtual and Mixed Reality. Lecture Notes in Computer Science*. Springer, Berlin, Heidelberg.

Russell, S.J., Norvig, P. (2003). *Artificial Intelligence: A Modern Approach (AIMA)*, Upper Saddle River, New Jersey, Prentice Hall.

Sidorov, S. V. *Mental'nye karty na lektsii po pedagogike* [*Mental Maps at a Lecture in Pedagogy*], available at: http://sv-sidorov.ucoz.com.

Schwartz, J., Begley, S. (2003). *Mind and the Brain: Neuroplasticity and the Power of Thought*, Harper Perennia.

Schreiner, G., Lyddon, W.J. (2002). Modern and Postmodern Metaphors of Self, Mind and Memory. In: *Cognitive Psychotherapy Toward a New Millennium: Scientific*

*Foundations and Clinical Practice,* New York, Springer Science + Business Media, 420 p.

Shapiro, L. (2006). *Embodied Cognition.* New York, Routledge Press, 312 p.

Solso, R.L. (2006). *Kognitivnaia psikhologiia* [*Cognitive Psychology*]. Saint Petersburg, Peter, 589 p.

Stepanov, M.A. (2011). *Opyt myshleniia tela* [*Bodily Thinking Experience*]. Saint Petersburg, 26 p.

Stepanova, T.A. (2014). *Teorii algoritmicheskogo myshleniia* [*Algorithmic Thinking Theory*]. Krasnoyarsk, V.P. Astafyev Krasnoyarsk State Pedagogical University, 72 p.

*Teoriia i metodika fizicheskogo vospitaniia* [*Theory and Methods of Physical Education*] (1990). Ed. Ashmarin, B.A., Moscow, Prosveshchenie, 210 p.

Fomin, N.A., Vavilov, Iu.N. (1991). *Fiziologicheskie osnovy dvigatel'noy aktivnosti* [*Physiological Basis of Motor Activity*]. Moscow, 152 p.

Wilson, A.D., Golonka, S. (2013). Embodied Cognition is not what you Think it is. In: *Frontiers in Psychology*, 4, 58–62.

## Развитие многомерного алгоритмического мышления с использованием когнитивной учебной платформы

**Н.И. Пак[а, б], Т.А. Степанова[а],**
**И.В. Баженова[б], И.В. Гаврилова[а]**
*[а]Красноярский государственный педагогический университет им. В.П. Астафьева*
*Россия, 660049, Красноярск, ул. Ады Лебедевой, 89*
*[б]Сибирский федеральный университет*
*Россия, 660041, Красноярск, пр. Свободный, 79*

*Проблема развития алгоритмического мышления в рамках курсов по информатике, компьютерной и информационной технологиям остается актуальной несмотря на множество исследований, проведенных в этой области. Цель данной статьи — обосновать применение когнитивной учебной платформы для дальнейшей реализации соответствующих методов и инструментов обучения, раскрыть сущность многомерного алгоритмического мышления и представить инструменты обучения программированию, основанные на когнитивном и телесном подходах. Авторы статьи приходят к заключению, что многомерное алгоритмическое мышление необходимо развивать путем применения алгоритмических карт для различных стилей мышления, когнитивных и эмпирических задач, а также с помощью кинестетических симуляторов. Такие инструменты обучения задействуют все каналы восприятия,* *способствуют лучшему пониманию и усвоению дисциплины «Алгоритмизация и программирование». Результаты исследования могут быть полезны преподавателям информатики и программирования как в школах, так и в высших учебных заведениях.*

*Ключевые слова: когнитивная учебная платформа, многомерное алгоритмическое мышление, когнитивные алгоритмические карты, телесный подход.*

*Научная специальность: 13.00.00 — педагогические науки.*