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The Definition of Algorithmic Thinking

Sadykova O.V.
Faculty of Information Technologies and Mathematics
NVSU
KhMAO, Nizhnevartovsk, Russia
nggu-it@mail.ru

Il'bahtin G.G.
Faculty of Information Technologies and Mathematics
NVSU
KhMAO, Nizhnevartovsk, Russia
guenil@mail.ru

***Abstract* – This article provides a definition of "algorithmic thinking" and provides examples of authors who believe that algorithmic thinking is thinking. Moreover, they think it is not just thinking, but a system of discrete actions, which are called thinking ways. These ways of thinking are a system that consists of two types of components: intermediate tasks and final tasks (goal), and an understanding of the operations that should lead to the sequence and execution of these tasks.**

Keywords – thinking; algorithmic thinking; definition

The concept of algorithmic thinking cannot be considered without understanding the basic essence of the "algorithm". It is important, because the algorithm is the main tool of the data processing process, and the end result of algorithmic thinking. Algorithmic thinking today is defined as a system of thinking techniques aimed at solving problems, which is not unambiguous, as before the interaction, we must determine not only the presence, but also the scheme of the "foreign" algorithm, and only then can embed your algorithm. That is why, it can be argued that it is difficult to imagine a problem, the solution of which does not require interaction with anything. Our statement about the ambiguity of algorithmic thinking is based on the existence of different points of view on the concept of algorithm.

Chronologically, the term "algorithm" comes from the name of the medieval Uzbek mathematician al-Khwarizmi, who received this, the most famous part of his name by the locality of residence. But he gained fame thanks to the introduction of rules for performing four arithmetic operations in the decimal system. "The process of performing arithmetic operations was called an “algorizm" [1].

Fundamentally, in our opinion, humanity is obliged to the philosophers of Greece, the times of the 300s BC for the emergence of the algorithm. They used in the calculations presented by Euclidean division algorithm and the algorithm for calculating the greatest common divisor of two integers.

However, almost until the XVII century, the concept of algorithm was understood as teaching the art of counting with the help of numbers. As an example, we can cite the work on arithmetic of John Sacrobosco "Algorithmus vulgaris", which for several centuries was the main textbook on calculations in the decimal positional number system in Europe.

The understanding of the algorithm as a sequence of strict procedures for performing arithmetic operations close to our understanding is presented in 1684 by G.V. Leibniz in his work "Nova Methodus pro maximis et minimis, itemque tangentibus...". Here he first used the word algorithm (algorithmo) in an even broader sense: as a systematic way to solve problems of differential calculus. Leonhard Euler, in "the Use of a new algorithm to solve Pelliano's problem" ("De su novia algorithm in problem at e Pelliano solvendo"). He presented the algorithm as a synonym for solving the problem close to the modern one.

By 1950, the term algorismus had been replaced by algorithm. In the XX century the algorithm not only confirmed the right to remain as a key concept of mathematics, but also in connection with emergence of electronic computers gradually expanded in the field of Informatics and other spheres.

For example, under the algorithm at the everyday life, we undoubtedly understand a strict sequence of any operations (actions), leading to the intended result. Examples of such algorithms are various instructions: recipes, the route from home to school, the operation of the washing machine, etc. The structure of this algorithm consists of individual steps, actions. The above definition is often found in school textbooks.

In the field of research related to the understanding of the word "algorithm", described in a generic way, we meet at works of B.A. Trahtenbrot, Ya.I. Grudenov [7], and in a brief dictionary of logic [6]. The algorithm in these definitions is a finite set of rules (set of instructions), allowing purely mechanical solution of any specific problem from the class of similar problems.

According to M. Broy, "an algorithm is a method with an exact (i.e. expressed in a precisely defined language) final description of the application of effective (i.e. practically feasible) elementary steps (processing)" [3].

From the presented definitions of the algorithm it follows that they are not exact mathematical definitions of the concept of "algorithm", because they explain the meaning of the word. Nevertheless, such formulations of the algorithm are close and understandable to a large number of people of different professions, are widely used in school education.

S.A. Beshenkov, A.A. Kuznetsov, E.A. Rakitina [12] separate the concept of algorithm in computer science and mathematics, pointing to a significant difference in this division. In their opinion, the algorithm in computer science is a formalized record of actions, the algorithm in mathematics is the formalized actions themselves (Turing machine and other approaches to the formalization of the concept).

According to H. Rogers [16], the algorithm is a deterministic procedure that can be applied to any element of a

class of symbolic inputs and which for each such input gives the corresponding symbolic output.

The constructed informal algorithm should take into account all the requirements for its development. These requirements are: mass, clarity, efficiency, discreteness and determinism. In other words, requirements are a set of properties that distinguish an algorithm from any prescriptions and ensure its automatic execution. Most often in the literature the properties of the algorithm are described approximately, intuitively.

All-round automation and computerization has led to the fact that thinking was inevitably compared with the work of the computer, and the person is considered in "tandem" with the computer. So, on the one hand, to more effectively use the technique, it is necessary to" talk " with him in one language, and this is the language of algorithms. On the other hand, algorithmic thinking – it is still thinking, and not action on the program and algorithm, as it happens with the computer, so it is very important to consider algorithmic thinking and its possibilities in modern conditions.

The concept of algorithmic thinking of schoolchildren is considered in the works of A.I. Bochkin, Ya.I. Grudenov, A.P. Ershov, G.A. ZHarkova, G.A. Zvenigorodskij, A.G. Kushnirenko, G.V. Lebedev, L.N. Polyakova, Yu.A. Pervin.

So, according to Yu.I. Grudenov [7], algorithmic thinking involves building skills to take the best possible decisions, i.e. aimed at the optimal solution to this problem. In this interpretation, it is essential that the way to solve the problem must be rational. On the other hand, this is extremely insufficient to describe all the components of the concept of algorithmic thinking.

A.I. Bochkin distinguishes logical-algorithmic style of thinking, identifying this concept with algorithmic thinking. In his opinion, this style of thinking is manifested in the following requirements for the skills of students:

- build logical statements about data properties and queries to search engines;
- operate inductive and deductive methods of mental operations in the analysis of their difficulties in working with computers;
- use the method of formalization for their intentions to solve the problem up to writing in algorithmic language [2].

According to G.A. Zharkova, L.N. Polyakova [9], applicable to the study of computer science, algorithmic thinking is characterized by the ability to divide tasks into successive interconnected blocks, taking into account a variety of design technologies.

A.P. Ershov, G.A. Zvenigorodskij, Yu.A. Pervin include the concept of algorithmic thinking "ability to plan the structure of the actions needed to achieve the goal by using a fixed set of resources" [8].

A.G. Kushnirenko, G. V. Lebedev consider algorithmic thinking as "the method and way that are necessary for the transition from direct control to software, from the ability to make to the ability to write the algorithm»

It is obvious that algorithmic thinking involves understanding the basic algorithmic structures, such as sequencing, fork, loop, transition, call. As well as it involves the ability to competently and effectively use these structures in the preparation of simple algorithms based on a limited set of elementary mathematical operations and build complex algorithms based on simple ones. The presence of advanced algorithmic thinking is a prerequisite for the ability to compile programs for electronic devices. If the learner does not have such thinking, even his knowledge of one or many language tools (programming languages) will be almost useless. This explains why often trainees demonstrate knowledge of specific operators, but cannot apply them in practice when solving a new problem. For example, knowing how a pre-test loop works in practice does not mean the ability to calculate the sum of a sequence of numbers using it. At the same time, the peculiarity of algorithmic constructions is that their inherent property is formalization, which makes it impossible to study them in isolation from a certain algorithmic language. T.N. Lebedeva in her dissertation research, understood this concept as a cognitive process characterized by the presence of a clear, expedient (or rational) sequence of committed thought processes with inherent detail and optimization of enlarged blocks, conscious consolidation of the process of obtaining the final result, presented in a formalized form in the language of the performer with the accepted semantic and syntactic rules [14].

Kopaev A.V. believes that it is a system of mental modes of action, techniques, methods and corresponding mental strategies that are aimed at solving both theoretical and practical problems and the result of which are algorithms as specific products of human activity [10].

S.D. Yazvinskaya [19] defines algorithmic thinking as an art and the ability to reflect, plan, provide for various circumstances and act in accordance with them, as well as the ability to solve various kinds of problems involving the preparation of an action plan for its resolution. The researcher believes that to form algorithmic thinking should already have a preschooler, it is necessary to teach him a selection of content challenges to build the algorithm for its solution.

Many researchers (A.P. Ershov [8], M.P. Lapchik [13], I. G. Semakin [17], Yu.A. Pervin [15]) believe that algorithmic thinking is a special way of thinking, based on the technology of step-by-step solution of the problem, and these steps must be a finite number.

In the definition of AT given by S.D. Yazvinskaya, the requirement to the species-generic relationship between the concepts is violated, since algorithmic thinking is, first of all, thinking, one of its types. And to call thinking art, from our point of view, it is impossible, because art belongs to a completely different concept.

A.P. Ershov, M.P. Lapchik, I.G. Semakin, Ya.A. Pervin give a definition of algorithmic thinking as a "way of thinking, but associate it exclusively with step by step solution of the problem. But this interpretation leads to a significant

narrowing of the concept of AT. It seems to us that AT can be manifested not only in the preparation of linear algorithms.

In A.G. Gein's definition, the emphasis is on the ways of thinking that make up a "system". But this definition does not reflect the specifics of algorithmic thinking associated with the fact that as a result of mental activity there is a model (system). This model consists of intermediate results and ways to achieve them, this is the peculiarity of algorithmic thinking.

TABLE I.

No.	Author	Definition
1	S.D. Yazvinskaya	*as an art* and the ability to think, plan, foresee different circumstances
2	A.P. Ershov, M.P. Lapchik, I.G. Semakin, Yu.A. Pervin	this is a special *way of thinking* based on the technology of step-by-step solution of the problem
3	A.G. Gein	the creation of the subject's *system of mental modes* of action, techniques, methods, mental strategies
4	Ya.I. Grudenov	*formation of the ability* to make the best possible decisions
5	G.A. Zharkova, L.N. Polyakova	*ability* to break tasks into consecutive interconnected blocks
6	A.P. Ershov, G.A. Zvenigorodskij, Yu.A. Pervin	*ability to plan the structure* of actions required to achieve a goal with a fixed set of tools
7	A.G. Kushnirenko, G.V. Lebedev	*the method and the way* that are necessary for the transition from direct control to software, from the ability to make to the ability to write the algorithm
8	A. I. Gazejkina, I.N. Slinkina.	cognitive process characterized by the presence of a clear, appropriate (or rational) sequence of mental processes committed with the inherent detail and optimization of enlarged blocks, conscious consolidation of the process of obtaining the final result, presented in a formalized form in the language of the performer with the accepted semantic and syntactic rules.

In the definition of Ya.I. Grudenov algorithmic thinking is forms of skills you can use to make the "best possible solution". The disadvantage of this deffinition is the relativity of the characteristics of a "best solution". The best solution is the one that is more preferable than the others in one way or another. Therefore, a solution preferred by one may not be acceptable to the other for some criteria and circumstances.

G.A. Zharkova, L.N. Polyakova give the following definition:"ability to divide tasks into consecutive interconnected blocks". They are among the first to consider as the main feature of "algorithmic thinking" the ability to discrete division of the task into blocks.

A.P. Ershov, G.A. Zvenigorodsky, Yu.A. Pervin describe algorithmic thinking as "the ability to plan the structure of actions necessary to achieve a goal with a fixed set of tools." But in our opinion, it is necessary to reveal the structure of actions in more detail. We understand by structure of actions as planning of actions, planning of intermediate results and final goal.

The concept of "algorithmic thinking" given by the authors A.G. Kushnirenko and G.V. Lebedev concerns the narrow field of"programming". In our opinion, algorithmic thinking should be possessed not only by a programmer, but also by every person.

A.I. Gazejkina, I.N. Slinkina in the same way as A.G. Kushnirenko, and V.G. Lebedev link the definition of "algorithmic thinking" consider in the subject area "programming". And the emphasis is on "programming".

Most authors believe that algorithmic thinking is thinking and moreover, it is not just thinking, but a system of discrete actions, which are called thinking ways. These ways of thinking are a system that consists of two types of components: intermediate tasks and final (goal), and an understanding of the operations that should lead to the sequence and execution of these tasks.

We highlight the signs of algorithmic thinking:

1. A system of thinking ways that:

a. Has a sequence of construction of the obtained results

b. Building a sequence of actions

c. Leads to the achievement of the goal

Give sequence obtain: results, interim facilities and lead to achieving meet the goal.

If algorithmic thinking will have all of the above features, we can call it "algorithmic thinking".

As a result, the following definition of algorithmic thinking can be given: Algorithmic thinking is a system of thinking methods that is necessary to build a sequence of obtaining intermediate results, planning the structure of actions and its implementation, leading to the achievement of the goal.

All of the above definitions do not have all the features of algorithmic thinking that we have listed, so they have drawbacks.

References

[1] Z.V. Alferova, Theory of algorithms. Moscow: Statistics, 1973, p. 3.

[2] A.I. Bochkin, Methods of teaching Informatics: Educational software. Mn: High. School, 1998, 431 p.

[3] M. Broy, Informatics. Fundamental introduction: 4 parts, p. 1. Moscow: Dialog-MIFI, 1996, p. 40.

[4] A.I. Hazeltine, Teaching students 5–7-graders to the object-oriented approach to the creation and use of information technology: diss... Cand. PED. Sciences. Ekaterinburg, 2004.

[5] A.G. Gein, “Mandatory minimum content of education in computer science: and in it we want to get to the bottom of it”, Gein: Informatics: ADJ. to newspaper "First of September", no. 38, pp. 9–24, 2001.

[6] D.P. Gorsky, A.A. Ivin, A.L. Nikiforov Concise dictionary of logic. Moscow: Education, 1991, 208 p.

[7] J.I. Grudanov, A study of the definitions, axioms, theorems. Manual for teachers. Moscow: Education, 1981, 95 p.

[8] A.P. Ershov, A.G. Zvenigorodsky, Yu.A. Pervin, “School Informatics (concept, status, prospects)”, Informatics and education, no. 1, pp. 3–19, 1995.

[9] G.A. Zharkova, L.N. Polyakova, "Logical problems of entrance examinations in Informatics", Informatics and education, no. 10, pp. 60–72, 2004.

[10] A.V. Kopaev, Algorithm as a model of algorithmic process. Retrieved from: http://www.rusedu.info/Article100.html

[11] A.G. Kushnirenko, G.V. Lebedev, "12 lectures on what a school course of Informatics is needed for and how to teach it", Informatics, no. 1, pp. 2–15, 1999.

[12] A.A. Kuznetsov, S.A. Beshenkov, E.A. Rakitina, "Modern course of Informatics: from concept to content", Informatics and education, no. 2, pp. 2–6, 2004.

[13] M.P. Lapchik, I.G. Semakin, E.K. Henner, Methods of teaching Informatics. Moscow: Academy, 2003, 624 p.

[14] T.N. Lebedeva, Formation of algorithmic thinking of schoolchildren in the process of teaching recursive algorithms in specialized classes of secondary school: diss. ... Cand. PED. Sciences. Ekaterinburg, 2005, 219 p.

[15] Y.A. Pervin, Methods of early teaching computer science [Text] : method. Manual. Moscow: Binom, 2005, 228 p.

[16] X. Rogers, Theory of recursive functions and effective computability. Moscow: Mir, 1972.

[17] I.G. Semakin, "From the aims of education to the content of school Informatics", Informatics and education, no. 2, pp. 23–32, 2002.

[18] I.N. Slinkina, The use of computer technology in the development of algorithmic thinking in younger students: Diss. .. Cand. PED. Sciences. Ekaterinburg, 2000.

[19] S.D. Yazvinskaya, Pedagogical conditions for the development of algorithmic abilities of preschool children in the process of cognition of the category of time: diss. ... kand. PED. Sciences. Stavropol: South. fader. Univ. of Illinois, 2009, 306 p.