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# Development of Algorithm Skills in Preschool Children

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**Abstract**

The aim of the present study is to present a technique to develop algorithm skills in preschool children. We determined and described a structure of algorithm skills in preschool children. The structure of algorithm skills included four major components: procedural, personal, regulatory, and communicative. The conditions to develop algorithm skills in preschool children involved game playing according to certain rules, organizing gaming activities according to algorithms provided by a preschool teacher, and creating developmental subject-based environment.


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*Keywords:* Algorithm; Algorithm skills; Structure of algorithm skills; Conditions to develop algorithm skills.

## 1. Introduction

Modernization of the educational system in Russia is characterized by dramatic changes at every level. One of the major characteristics is development of the common educational environment aimed at child's personality development. The Federal State Educational Standards for preschool education [1] sets down the objectives of preschool education. They are social age-based characteristics of possible achievements made by children after completing preschool education that may be a prerequisite to further educational activity. Psychological and pedagogical researches by Davydov V.V.[2] Elkonin D.B.[3] show that a child is ready to learn and is able to understand the aim of further activities, to plan their actions, to choose the means of reaching the goal, to control and self-control his or her activities. Developing algorithm skills in preschool children may contribute a lot to further learning activities. *An algorithm* is a set of actions involving the understanding of objectives of further activities, and undertaking a series of steps to solve practical and educational problems. Algorithm comprehension makes it possible to transfer the method of solving a problem to similar tasks. The ability to control, self-control, and correct is a characteristic feature of algorithm skills. An algorithm is one of the most

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ancient and fundamental concepts in mathematics and the theory of algorithms. Due to technological progress the concept of an algorithm has penetrated into various spheres of human life. Stolyar A.A. [4] provided an intuitive and meaningful definition of this concept describing it as a set of clear and precise actions in a definite order to solve any problem out of a number of similar ones. There are three *types of algorithms*. The *linear* algorithm is a sequence of actions carried out in strict order and only once. The *branching* algorithm is characterized by a certain condition that should be checked, and if it is true a sequence of steps is performed, if not another sequence of steps is performed. The *cyclic* algorithm includes some actions that should be repeated several times until a certain condition is met. Most of the current studies are focused on the development of algorithmic thinking and the style of thinking (Kopayev A.V., Tsarev S.E.) [5, 6], and the development of algorithmic culture (Lapchik M.P.) [7]. Russian psychological and pedagogical studies have addressed the problem of algorithmic abilities included in the structure of cognitive abilities (Yazvinskaya S.D.) [8]. The analysis of psychological and pedagogical studies showed us the need to develop algorithm skills in preschool children during rule-based game activities and to introduce the concepts of "rule" and "algorithm" into them. The *algorithm skills in preschool children* is an ability to work according to rules and models, to understand, use, apply, and develop algorithms, and analyze, correct the sequence of actions to reach the results, to transfer the acquired methods of action (algorithms) to new situations, and to describe clearly their activities to others. The *structure of the algorithm skills* of preschool children is divided into four parts called procedural, personal, regulatory and communicative .components (Voronina LV. et al.) [9]. The procedural component is responsible for the study of properties, types, and ways of writing algorithms, for their application and preparation. The personal component is aimed at developing the awareness of the importance of new knowledge. The regulatory component promotes the development of the ability to plan, monitor, and self-correct their activities. The communicative component stimulates the development of communication skills in preschool children due to their interaction with adults and group mates in the process of algorithmic activity. We elaborated a *technique of developing algorithm skills* in preschool children, starting with the middle group of children, and which included three stages: *Stage 1* (middle group) - the development of a child's ability to use linear algorithms for the solution of educational problems. At this stage the concepts of "plan", "algorithm" are not introduced. The teacher shows children linear algorithms; and preschoolers learn how to apply them. To achieve this objective the teacher creates a problematic situation. For example the task is to make a snowman. Firstly, the teacher says that it is necessary to decorate the area so the Grandfather Frost understands that the children are waiting for him to give them presents. The teacher asks: "What should we do?", "Why are we going to make a snowman?", "Show the card with the result that we need to get," etc. The teacher shows the "Make a snowman" algorithm at the same time enumerating every action: 1. Make a big snowball and put it on the ground. 2. Make a second snowball, but this time smaller than the first one. 3. Put the second ball on the first one, etc. *Stage 2* (senior group) - training preschool children to perform various kinds of algorithms, and developing initial skills to create algorithms. The development of the ability to create algorithms starts with the introduction of preparatory exercises and games, for example, the tasks may include following: continue the algorithm; fill in the missing steps in the well-known fairy tale; arrange the cards in the correct order, etc. An example of *Stage 2* is the algorithm for brewing tea. The teacher introduces a new character - a robot, which performs commands. To make the robot perform commands children should state them clearly and in the right order. The task for a branching algorithm is, for example, to make the algorithm "Boiling water in an electric kettle." *Stage 3* (preschool group) is consolidating algorithm skills and transferring the algorithms learned to various educational fields and activities. The teacher uses creative game tasks and then invites the group to analyze their activity, responding, for example, to the following questions: "What caused a change in the algorithm?", "Have you changed the algorithm to reach the results?" The teacher can use fairy tale characters, for example, "the Wizard of Reverse Time", which shows the algorithm in the reverse order. The children are to guess which process is on and are asked to perform the sequence of actions in the right order. The teacher gradually allows children more independence in performing and preparing the algorithm, and promotes goal-setting, monitoring, correction, and reflection made by children while performing various activities.

## 2. Methods

We conducted a study to identify the level of algorithm skills development and their characteristics in preschool children from preschool educational institutions in Yekaterinburg. The monitoring of the level of algorithm skills development in preschool children was performed at several stages: the primary (at the beginning of the study), the intermediate (after the training course), and the final one (when the study was completed). We identified the main indicators of skills development in preschool children in accordance with the objectives of a certain stage for each of the four structural parts of algorithm skills. We determined the following *indicators of algorithm skills development*. *The procedural part indicators* are as follows: a child in the *middle group* follows the rules of the game, listens to the teacher's instructions, he tries to apply the rule in his activity, he performs one or two-step action sequences (linear algorithms) and restores the step sequence using cards with the previously shown algorithm; in the *senior group* a child performs three-step linear algorithms, he performs branching and cyclic algorithms under the teacher’s supervision or using cards as prompts, he creates simple algorithms to achieve a goal under the teacher’s supervision and uses flowcharts as prompts in performing various algorithms; in the *preschool group* a child performs 3-to-4-step algorithms and creates various types of algorithms more independently, he transfers known algorithms to solve problems under teacher supervision, he changes the algorithm according to certain conditions under teacher supervision and uses algorithms in different types of their activity. *The personal part indicators* are the following: in the *middle group* a child understands that activity consists of a sequence of steps, and individual actions, he realizes that it is important to follow the rules (algorithms) to achieve the result, he attempts to subordinate their motives and evaluates new knowledge and activities; in the *senior group* a child understands the importance of applying algorithms to problem solving. He subordinates their motives and role in the game according to certain rules and shows interest in developing new algorithms*;* in the *preschool group* a child understands the importance of applying algorithms to deal with cognitive tasks. He shows interest in finding common methods (algorithms) to solve the problems belonging to one type and assesses their activity from the point of generally accepted rules. Similar rates were determined for both *communicative* and *regulatory parts*.

We used observation techniques, tests, game tasks, conversations, and diagnostic methods in our study. To evaluate the efficacy of training at every stage of algorithm skills development we introduced the following rates: $n = 3$ (a highly developed skill in the age group), $n = 2$ (a well developed skill in the age group), $n = 1$ (a partially developed skill in the age group), $n = 0$ (an underdeveloped skill in the age group). Then the diagnostic cards were filled in for all preschool children participating in the study.

## 3. Results and discussion

The experimental training took place in preschools №№ 75, 366, 556 and 587 in Yekaterinburg. The training process involved 120 preschoolers: 60 children in the control group, and 60 children in the study group. The process of skills development consisted of three stages and started in the middle group, later on the training continued in the senior and preschool groups. A comparative analysis of the level of algorithm skills development in preschool children from both study and control groups was carried out. Table 1 shows that the dynamics of algorithm skills development in preschool children from the control group was insignificant, whereas we found significant positive dynamics in algorithm skills development in preschool children from the study group. Due to the developed teaching technique the level of skill development in each part increased, on the average, in 69.3% of the children from the study group and in the control group this rate increased only in 20.3% of the children.

Table 1. Quantitative analysis of the level of algorithm skills development in preschool children

| Structure of algorithm skills | Skill Levels | Control group | Study group |
|---|---|---|---|

| (Parts) | Skill development | Primary stage | Final stage | Primary stage | Final stage |
|---|---|---|---|---|---|
| Procedural | 0 | 2 | 2 | 4 | 1 |
| | 1 | 34 | 20 | 36 | 4 |
| | 2 | 20 | 34 | 18 | 35 |
| | 3 | 4 | **4** | 2 | **20** |
| Personal | 0 | 3 | 6 | 5 | 0 |
| | 1 | 34 | 22 | 30 | 7 |
| | 2 | 21 | 30 | 20 | 31 |
| | 3 | 2 | **2** | 5 | **22** |
| Regulatory | 0 | 5 | 8 | 6 | 1 |
| | 1 | 35 | 23 | 31 | 5 |
| | 2 | 15 | 21 | 21 | 37 |
| | 3 | 5 | **8** | 2 | **17** |
| Communicative | 0 | 6 | 4 | 4 | 1 |
| | 1 | 30 | 29 | 31 | 5 |
| | 2 | 22 | 22 | 20 | 31 |
| | 3 | 2 | **5** | 5 | **23** |

Preschool children in the study group showed higher level of planning activity development. They tended to analyse the aim of the given activities, and tried to trace the steps in order to achieve the desired result. The study group children demonstrated further development of personal qualities, increased self-regulation, self-control, and self-evaluation of their actions. They learned to transfer algorithms to the solution of similar problems under teacher supervision, and the use of algorithm skills in different types of their activities. Preschool children understood the importance of applying algorithms and showed interest in finding general ways to solve similar problems. The outcomes of the diagnostics of the communicative part of algorithm skills, and observation of children's gaming activities showed that the majority of preschool children mastered the skills of working in teams. They were involved in the process of solving team tasks during the game, effectively cooperated in pairs and small groups to achieve the desired result. They were able to ask questions independently without any difficulties, and reflect their actions in speech in the process of algorithmic activity.

## 4. Conclusion

Our research suggests that algorithm skills development in preschool children of 6-7 years of age is a prerequisite for preparing them for successful transition to the next stage of their studies.

The above conditions in the process of algorithm skills development may contribute to motivation development, cognitive activity, goal-setting, planning, evaluation, and self-monitoring. They may have a positively influence on the learning activities of future school children.

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