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Zak A. Problem solving strategies for younger schoolchildren

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Abstract. *The article presents a study devoted to studying the nature of the distribution of problem-solving strategies among primary schoolchildren. 81 first-graders, 76 second-graders, and 75 third-graders took part in individual experiments. Children solved spatial-combinatorial problems using the "Jumping Cubes" method in an objectively active manner. As a result of the study, it was shown that in the second year of school, most children move from a strategy based on a non-generalized understanding of the subject content of the problems being solved to strategies related to the identification of the general principle of solving problems and specific principles. In the future, we plan to characterize the distribution of the noted strategies among fourth-graders.*

Keywords: *first, second and third grade students, individual experiments, spatial-combinatorial problems, "Jumping Cubes" technique, problem solving strategies.*

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1. Introduction.

One of the important problems of developmental and educational psychology is in describing the characteristics of strategies used by primary schoolchildren when solving problems of a search nature. This refers to strategies based on different approaches to solving problems - empirical, associated with a situational, non-generalized understanding of the subject content of problems, and theoretical, associated with a generalized understanding.

In solving this problem in theoretical terms, we relied on the above-mentioned approaches developed in Russian psychology, which were generally proposed by S.L. Rubinstein [6] and further specified in the studies of V.V. Davydov [2] and his followers [1, 3]. In the experimental plan, we relied on the characteristics of a two-part experimental situation that we developed (see, for example, [4]), related to solving problems (the first part) and their generalization (the second part).

The general goal of this study was, therefore, to establish the distribution in the mental activity of junior schoolchildren when solving problems of strategies that are manifested in the implementation of the above-mentioned approaches to understanding the subject content of problems.

In particular, the experiments presented below with primary schoolchildren were aimed at establishing how the strategies used by children in solving problems are related to their age and what the dynamics of changing strategies are as children study at school. In particular, it was important to find out which problem-solving strategies are more common among first-, second-, and third-graders.

The experimental work was based on the assumption that as children progress through elementary school, when solving problems, they move from less sophisticated strategies associated with a non-generalized understanding of the content of problems to more sophisticated strategies that are associated with a generalized understanding of the content of problems.

2. Materials and methods.

To conduct the study, the “Jumping Cubes” technique was developed. It included three tasks involving moving wooden cubes across a game board. One cube was blue, another was red, and the third was green. Each cube moved according to a special rule. A total of 232 elementary school students participated in the study: 81 first-graders, 76 second-graders, 75 third-graders.

The experiments were carried out individually as follows.

In the first part of the experiment, the child was taught to make a single move for each of the three cubes used in solving problems (the children were told that these were new chess pieces). In the second part, the child solved the proposed problems.

In the third part, he answered the experimenter, who said: “You solved three problems. Many children solved these same problems. Some children said that all tasks are different. Other children said that all the tasks are similar. The children of the third group said that among these tasks there is a task that does not fit the other two and is different from them. Which child do you think said it correctly?” After any response from the child, he was asked to justify his opinion.

Let us consider in detail the content of each part of the experiment.

2.1.First part of the experiment

At the very beginning of the first part of the experiment, the child was given a playing field of the same size as a chessboard: 8 cells horizontally and 8 cells vertically (each cell had the shape of a square with a side of 3 cm - Fig. 1).

Then he was given a blue cube and told: “This cube is a new chess piece. He can walk across the cell field directly into an adjacent cell and diagonally. He can also jump. His jump is equal in length to two different steps in one direction - straight and oblique or oblique and straight" (Fig. 2, options A, B, C, D).

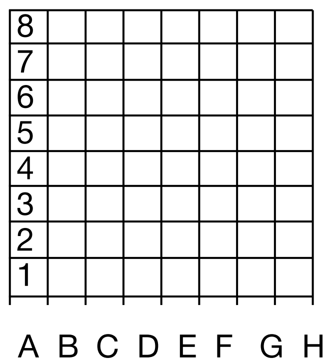
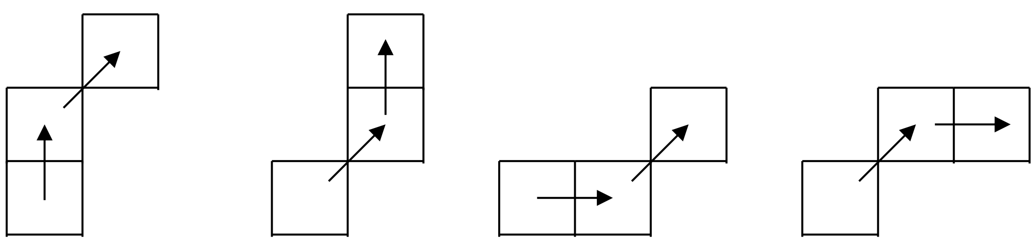


Fig. 1. Playing field

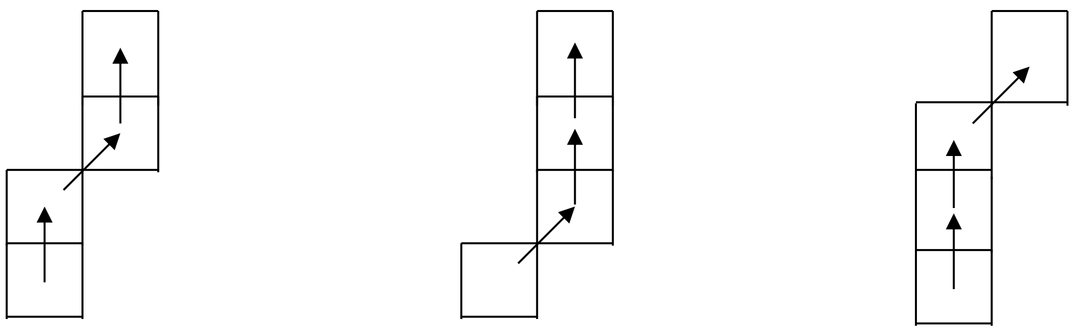


Option A Option B Option C Option D

Fig. 2. Options for moving the blue cube

Next, the child tried to walk and jump with a blue cube from different cells of the playing field (see movement options A, B, C, D). At the end of learning how to move this cube, the child was given a control task, where it was required to show all possible jumps of the cube from some central cell of the playing field, for example, from cell D5 (it should be noted that the names of the cells of the playing field, consisting of children did not master letters and numbers).

After the child mastered the steps and jumps of the blue cube, he was asked to learn how to move the red cube (Fig. 3, options A, B, C). One of his steps was an oblique movement to an adjacent cell (see the second step of the cube in option A, the first step in option B, the third step in option C).



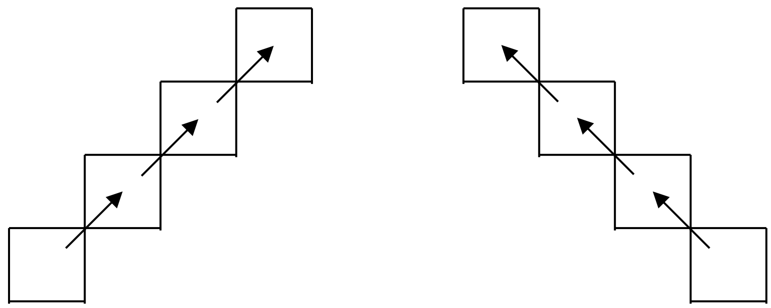
Option A Option B Option C

Fig. 3. Options for moving the red cube

The other two steps involved moving the cube directly to the adjacent square (see steps one and three in option A, steps two and three in option B, steps one and two in option C).

The child was first shown how a red cube walks and jumps, and then they were asked to make a series of jumps. Finally, the child was given a control task: one of the central cells of the field was indicated (for example, E4) and asked to perform all possible jumps from this cell with a red cube. After successfully completing this task, he was presented with a green cube.

The green cube steps into the adjacent cell only obliquely and its jump is equal to four such steps (Fig. 4, options A and B).



Option A Option B

Fig. 4. Options for moving the green cube

The child was first shown how a green cube walks and jumps, then they were asked to independently perform individual jumps from different cells of the playing field. After everything, the child had to complete a control task - show all the possible jumps of a green cube from some central cell of the playing field, for example, from cell D4. The first part of the experiment ended with mastering the jumping of the green cube.

2.2.Second part of the experiment

In the second part of the experiment, as noted, the children solved three problems. In the first task, you had to get the blue cube into cell D3 in two jumps from cell B3. To do this, the experimenter placed a blue cube in cell B3, and a white cardboard circle in cell D3.

After successfully solving the first problem (either completely independently or with the help of an experimenter), the child was asked to solve the second problem, which required making two jumps with a red cube. To do this, the experimenter placed it in cell C2, and a cardboard circle, the location of which indicated the point where the red cube should land after two jumps from cell C2, was located in cell E8.

After successfully solving the second problem (either independently or with the help of the experimenter), the child was asked to solve the third problem, which required him to make two jumps with a green cube. To do this, it was placed in cell A4, and the cardboard circle was placed in cell G4.

The solution to the third problem ended the second part of the experiment.

2.3. Third part of the experiment

In the last part of the experiment, as indicated above, the child was asked to evaluate the proposed opinions about the problems solved in the second part of the experiment, and thereby express his judgment: "... all problems are different...", "... all problems similar...", "...one task is different from the other two...".

In accordance with the provisions that make up systemic ideas about thinking (see, for example, [3]), we interpreted the child's opinion about problems as a reflection of the peculiarities of his understanding of the substantive content of the solved problems.

So, if the child believed that all problems were different because, for example, they used cubes of different colors, or because, for example, all the cubes walked and jumped differently, then in these and similar cases it was accepted that the child solved problems based on a situational, empirical understanding of their subject content [5]. This could be judged by the fact that the child did not highlight the internal unity of the content of the problems being solved. In this case, he judged the tasks by the characteristics of their external conditions: the characteristics of either the movements of the cubes, or their color, or the location of the jumps on the playing field.

If the child believed that all problems were similar, pointing out, for example, external features of their conditions, such as the fact that all problems are solved in two jumps, or that in all problems you need to move cubes across a cell field, or that In all tasks you need to get into a cage where there is a cardboard circle, etc., then in these and similar cases we also accepted that the child (just as in the previous case) solved problems on the basis of situational (empirical)) understanding their content, since I judged them based only on the external features of their conditions.

Some children also believed that the tasks were similar, but on different grounds. The children pointed out that in all problems the jumps were the same (i.e., the second jump repeated the first), or that in each problem the main difficulty was to find the first jump, since the second jump could be don't look.

In these cases, we accepted that these children solved problems on the basis of a generalized understanding of their subject content, in particular, on the basis of an understanding of the general principle of their construction and solution [5].

Indeed, the proposed three tasks belong to the same class of tasks involving two actions to move any objects according to certain rules. This class is based on the principle that the key to successfully solving two-move problems should be to find a point between the start and end points of the route that simultaneously serves as the end of the first move and the beginning of the second. It is this principle, as it seems to us, that was formulated by the children in a form accessible to them in the course of expressing judgments about the tasks and its justification.

Along with the children who considered the problems different or similar (for various reasons given above), there were children who believed that among the proposed problems there was one that did not fit the other two. One part of the children of the last group believed that the third problem did not fit the other two, because "... in it the figure jumps with a turn...", and in the first and second problems "... the figures jump without turning...". Another part of the children in the group under discussion believed that the second task was not suitable for the other two because it was more difficult than the other two.

Qualifying the opinions of these subgroups of children, it should be said that they reflect the children's situational understanding of the content of the problems they solved. Thus, pointing out the difference between the third task and the first two, children are actually guided by the external features of the task conditions, in particular, by the features of the movement of the figures, which were known to them even at the stage of mastering the rules of their movement. When characterizing the differences in the second problem, the children were guided by their impressions of the process of solving all three problems, and not by the features of their subject content.

The third part of the children, belonging to the group that pointed out the difference between one task and the other two, believed that the second task was not suitable because in it the movement of the cube had a different route. In particular, the children noted that in the second problem all the jumps "...are made along the same line..., go in one direction...", and in the first and third problems the figures "... walk straight and back..., forward and backward...". In these cases, we assumed that children had a generalized understanding of the problems they solved, associated, in particular, with the identification in their subject content of specific principles for constructing and solving individual subclasses of problems of a given class [5].

Indeed, of the three proposed tasks, two (the first and the third) belong, according to our plan, to one subclass of the above-mentioned class of tasks in two actions, and the second task belongs to another: the first subclass includes the so-called “mirror” (or “symmetric”) problems in which the second jump is, as it were, a mirror image of the first, and the second subclass of problems does not have such mirroring, since the second jump is a literal repetition of the first.

The group of children under discussion characterized precisely this internal difference between the indicated subclasses in a form accessible to them, thereby pointing to the different specific principles underlying the construction and solution of these problems.

Thus, the children’s judgments about the problems expressed by them in the third part of the experiment characterized different levels of their understanding of the subject content of successfully solved problems: situational understanding, generalized understanding associated with identifying the general principle for solving all three problems, and generalized understanding , associated with the identification of specific principles for solving individual subclasses of problems of the proposed class.

3. Results.

As noted, 232 elementary school students took part in individual experiments. Of these, 81 schoolchildren were in first grade, 76 schoolchildren in second grade, 75 schoolchildren in third grade.

Based on the results of individual experiments, the distribution of subjects into three groups was established. The first group consisted of students who solved problems based on a situational (empirical) understanding of their subject content, the second group consisted of students who solved problems based on identifying the general principle of constructing and solving the proposed problems, the third group consisted of students who solved problems based on identifying specific principles of construction and solutions to various subclasses of the proposed problems.

The quantitative characteristics of the noted three groups of subjects are presented in the table.

Table

Number of students who made up the first, second and third groups in the first, second and third grades of primary school (in%)

Classes	Number of students	Groups of subjects		
		First	Second	Third
1	81	67,7**	13,7*	18,6*
2	76	47,4**	23,7	28,9
3	75	37,3	29,3*	33,4*

Note:* $p < 0.05$; ** $p < 0.01$.

The data presented in nable reflect the general trend in the change in the distribution of levels of understanding of the subject content of tasks in primary school age from the first to the third grade. Analysis of the presented data allows us to note the following features of changes in the distribution of students in the first, second and third grades of primary school.

Thus, among the subjects of the first group in the second grade, in relation to the first grade, the number of children solving problems based on a situational (empirical) understanding of their subject content significantly decreases: the difference in indicators of 67.7% and 47.4% is statistically significant (at p <0.01).

At the same time, among the subjects of the second and third groups, respectively, the total number of students who solved problems based on a generalized understanding of their subject content increases - in the first grade there were 32.3% of such students (13.7% and 18.6%), and in in the second grade there were significantly more of them - 52.6% (23.7% and 28.9%): the difference in indicators of 32.3% and 52.6%% is statistically significant (at p < 0.01).

At the same time, it should be noted that from the first to the third grade the number of children who solved problems based on highlighting in their subject content the general principle of constructing and solving all proposed problems increases (the second group of subjects) - in the first grade there were 13.7% of such children. , in the third grade – 29.3%: the difference between 13.7% and 29.3% is statistically significant (at p < 0.05).

Also, from the first to the third grade, the number of children who solved problems based on identifying in their subject content specific principles for constructing and solving two subclasses of problems among those proposed increases (the third group of subjects) - in the first grade there were 18.6% of such children, in the third grade - 33.4%: the difference between 18.6% and 33.4% is statistically significant (at $p < 0.05$).

Thus, the results of individual experiments confirm the initial assumption of the study. Indeed, as children study in the second and third grades, more advanced problem-solving strategies are formed, associated, in particular, with solving problems based on a generalized understanding of their subject content. In this case, two strategies for a generalized understanding of the subject content of the problems being solved are implemented. One strategy for solving problems involves identifying a general principle for constructing and solving all proposed problems. Another strategy for solving problems involves identifying specific principles for constructing and solving both subclasses of problems among those proposed.

4. Conclusion.

4.1. General characteristics of the study

So, we conducted a study devoted to the study of strategies used by junior schoolchildren when solving problems of a search (non-standard) nature. In individual experiments, children were asked to solve spatial-combinatorial problems in an objective-active manner. These tasks required finding a path between two proposed cells on a playing field of 64 cells. In this case, cubes of different colors were used, moved according to certain rules, which the student learned at the preliminary stage (before solving problems).

As a result of individual experiments in which 81 first-graders, 76 second-graders, and 75 third-graders took part, it was shown that children actually change their problem-solving strategies with age (from first grade to third grade). In the first grade, a strategy based on a non-generalized understanding of the subject content of tasks prevails. This strategy was followed by a significant majority of students – 67.7%.

In the second grade, the distribution of strategies changed, since now the majority of children (albeit insignificant) used strategies based on a generalized understanding of the subject content of the problems when solving problems - such children were 52.6%. In the third grade, a significant majority of children - 62.7% - adhered to a strategy based on a generalized understanding of the subject content of the tasks. Thus, as a result of the study, it was shown that, indeed, as children study in primary school, when solving problems, they move from implementation of less advanced strategies for solving problems associated with a non-generalized understanding of the content of the proposed tasks, to more advanced strategies that are associated with a generalized understanding of the content of the proposed tasks.

4.2. Scientific significance of the study

The study obtained new knowledge characterizing the distribution of strategies of mental activity when solving problems by primary schoolchildren. For the first time, it was shown using the material of solving spatial-combinatorial problems in a subject-active form that in the second year of primary school, most children, when solving problems, move from strategies associated with a non-generalized understanding of the subject content of the problems being solved to strategies associated with a generalized understanding.

This knowledge expands and refines the ideas of developmental and educational psychology about the patterns of intellectual development of children at primary school age. In particular, knowledge that characterizes the distribution of empirical (non-generalized) and theoretical (generalized) thinking among schoolchildren studying in the first, second and third grades of primary school is important.

4.3.Further goals in learning problem solving strategies in elementary school

It is planned to conduct a study of the characteristics of the distribution of strategies associated with non-generalized and generalized understanding of the subject content of problems among fourth-graders. In this case, just as in the study under discussion, experiments with children will be carried out individually and using the material of the “Jumping Cubes” technique.

It is necessary to determine to what extent the results obtained in our study based on the problems of the “Jumping Cubes” technique, solved in an objective-active form, will differ from the results obtained on the material of the problems of the same technique, but solved in a visual-figurative form.

It is also necessary to establish how much the results obtained in the study based on the solution of spatial-combinatorial problems will differ from the results obtained in the study, where children were asked to solve plot-logical problems of varying degrees of complexity.

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