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OPPORTUNITIES FOR FORMING REASONING SKILLSIN PRIMARY SCHOOL

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Abstract
The purpose of the study was to determine the effectiveness of a longitudinal intervention aimed at improving reasoning skillsin 10-year-old children (4th grade). The intervention program titled 'Reasoning 1' includes 8 types of plot-logical tasks of non-academic content related to deductive reasoning. Each type of task is proposed in four structural options: find the answer, find the question, find part of the conditions, change the answer, replacing part of the conditions. The control group consisted of 117 students, the experimental - 122 students who participated in 32 group classes (weekly, from September to May). The initial and final diagnostics of the reasoning based on the material of crypto-arithmetic problems of various complexity was carried out. The study showed that classes in the school curriculum and the program "Reasoning 1" contribute to the improvement of reasoning to a much greater extent than classes only in the school curriculum. In further studies, it is planned to determine the extent to which the "Reasoning 1" program helps to improve reasoning in 11-year-old children.

Keywords: reasoning skills, improvement, longitudinal intervention,children 10 years old, school curriculum for grade 4,the program "Reasoning 1".

1.Introduction

1.1. The study of reasoning in primary school students

The process of forming and using judgments to create a coherent line of reasoning in children has been studied quite extensively [20]. Some studies dealt with various types of reasoning on mathematical material related to fractions [2], proportions [3], simple multiplicative reasoning in problems with integers [11] and analytical reasoning [4]in elementary and middle school students. Other studies have shown that iconic [22] and digital [29] modeling positively affects children's spatial thinking. Algebraic thinking research has examined how children analyze the relationship between numbers in addition problems [16] and their relative thinking skills [9]. Researches devoted to deductive thinking have considered the solution of logical problems with positive and negative statements [1] and the performance of verbal tests [8]. Available data also show that inductive thinking skills in children are positively associated with physical activity [14], visual (building blocks and pictures) and verbal (textual) use of material [17], various interventions [31] and that learning based on computer games can significantly improve the skills of deductive thinking when solving mathematical problems [19]. Research on scientific thinking has noted the importance of problem-solving skills and spatial abilities [15] in its development, the positive impact of computer learning [5] and age-related changes in its implementation [13]. Finally, the study of the general aspects of children's reasoning made it possible to note the positive impact of the intelligence enhancement program on reducing logical errors in abstract reasoning [22], as well as the positive role of using augmented reality to improve scientific thinking [27] and verbal reasoning [24].

1.2. General characteristics of the study

The intervention evaluated in the present study is rooted in the activity theory developed by Russian psychologist Rubinshtein [26], Leontiev [12], Teplov [28], and Davydov [6]. According to the provisions of this theoretical framework, activity is considered within an integrated environment that includes the actor (subject), object (the goal of activity), artefacts (tools of mediation), community that may impose rules or expectations on activity, and division of labor, which together lead to an outcome [7] Tools/artefacts are shaped by history and culture and serve as mediators of internal and external activity. In case of developing reasoning, tools/artefacts can be conceptualized as the materials that can mediate students reasoning towards the goal of developing new strategies of inferentialthinking (object) in elementary school students.

The purpose of the study was to determine the effectiveness of a longitudinal intervention in improving deductive reasoning in children of 10 years old. In the preliminary experiment, 18 children (experimental group) solved the problems of the “Reasoning 1” program in 16 lessons (two lessons per week) for two months. Before and after all classes, these children and 18 students of the same age who did not participate in the classes (control group) solved crypto-arithmetic problems[34]. The results showed that after classes under the program "Reasoning 1" the children of the experimental group solved the indicated problems more successfully than the children of the control group. Based on these findings, the hypothesis of the present study was as follows: the proposed intervention will improve the reasoning skills of elementary school students.

This present study consisted of three phases. At the first stage, 117 students of the control group and 122 students of the experimental group solved crypto-arithmetic problems of varying complexity to determine the level of development of the ability to reason. At the second stage, 32 lessons were conducted with the students of the experimental group on the material of the “Reasoning 1” program (from September to May, one lesson per week). In the third stage, the students of both groups again solved the same crypto-arithmetic problems as in the first stage. The method and results of the experiment are reported in the subsequent sections.

2. Materials and methods

2.1. Participants and data demonstration tools

The study involved a total of 239 children (117 — control group, 122 — experimental) aged 9 years 9 months to 10 years 3 months (mean = 10.09; Standard deviation =2.74). There were 57 boys and 60 girls in the control group, and 59 boys and 63 girls in the experimental group, respectively. Children were not specifically selected to participate in the experiment. The subjects were ordinary students who were allowed by their parents to participate in the “Reasoning1” classes.They studied in ordinary classes in two ordinary schools.The control group consisted of two classes of one and two classes from another school, and the experimental group consisted of two classes of the first and two classes from the secondschool.

To calculate the results indicating improvement of children's reasoning skills , the Fisher test was used. This special criterion is to compare the difference between two variation series. The following formula was used (1):

$$\varphi * \text{ emp.} = (\varphi 1 - \varphi 2)\sqrt{\frac{n_1 \times n_2}{n_1 + n_2}}, \quad (1)$$

Where φ1 is the angle corresponding to a large percentage, φ2 is the angle corresponding to a smaller percentage, n1 - the number of observations in the sample 1, n2 is the number of observations in sample 2. The significance level φ* of the empirical value is determined by a special table [34] The larger the value of φ*, the more likely that the differences are significant.

2.2. General content of the program "Reasoning 1".

“Reasoning 1” program was developed on the basis of the “Intellectics” course of non-academic content for children 6–10 years old [35– 40]. This course is being used by teachers in many schools in different regions of Russia to enrich primary education intellectually.

The Reasoning 1 program includes 8 groups of classes, 4 classes in each group - a total of 32 classes. In all classes, it was proposed to solve the plot-logical problems associated with the implementation of deductive reasoning, since it was necessary to draw a conclusion based on general (large premise) and private (lesser premise) information. In each group of classes, children solved only one type of plot-logical tasks. In four odd groups, - 1, 3, 5, 7, - it was proposed to solve four types of problems with attributive judgments, in even groups - 2, 4, 6, 8, four types of problems with relational judgments (see the appendix).

Examples of intervention tasks.

Group 1. Tasks with attributive judgments.

Lesson 1.

Task A: "Find the answer." For example: “Alik, Borya and Vova studied music. Someone played the trumpet, someone on the accordion, someone on the violin. Alik played the accordion, Borya played the trumpet or the accordion. Who played the violin? ”

a) Borya, b) Nina, c) Alik, d) it is not known who.

Task B: "Check the answer." For example: “One student was solving a problem:“ Dima, Lenya and Borya kept animals at home. Someone had a dog, someone had a cat, someone had a turtle. Dima had a cat. Lenya had a cat or a dog. What kind of animal did Borya have? ” The student replied: "Turtle."

a) the answer is correct, b) the answer is incorrect

Lesson 2 "Find a Question." For example: “Alla, Galya and Vera jumped high. Someone jumped 1.5 meters, someone - 1.4 meters, someone - 1.3 meters. Alla

jumped 1.5 meters, Galya jumped 1.3 meters or 1.5 meters. ” What question can be answered by the terms of this task?
a) Where did the girls jump high? b) Who jumped 1.6 meters?
c) Who jumped 1.5 meters? d) To what height did Vera jump?

Lesson 3 "Find part of the condition." For example: “Oleg, Gena and Vitya went on a trip: someone on a plane, someone on a train, someone on a ship. Oleg traveled on a ship. [.....................]. Who traveled by train? ” What do you need to know to answer the question?
a) [Gene traveled on a horse], b) [Victor traveled on foot],
c) [Gene traveled by plane or by ship], d) [Igor traveled by plane].

Lesson 4. "Change the answer." For example: “Dasha, Zhenya and Katya painted birds. Someone drew an eagle, someone - a parrot, someone - a sparrow. (1) Eugene painted an eagle. (2) Dasha painted a sparrow or an eagle. Who painted the parrot? ” (Answer: Katya painted a parrot).
What sentence should replace sentence (2), so that the correct answer would be "Dasha was drawing a parrot."
a) Katya painted an eagle, b) Katya painted a parrot,
c) Katya painted a sparrow or an eagle; d) Zhenya painted a sparrow.

Group 2. Tasks with relational judgments.
Lesson 1.
Task A: "Find the answer." For example: “Misha, Kolya and Vova crossed the river. Misha swam faster than Kolya. Kolya swam faster than Vova. Who swam the slowest? ”
a) Kolya, b) it is not known who, c) Vasya, d) Misha.

Task B: "Check the answer." For example: “One student solved the problem:“ Katya, Vera and Marina painted animals. Vera drew less than Katya. Katya drew less than Marina. Who painted animals the most? ” The student answered: "Katya."
a) the answer is correct, b) the answer is incorrect

Group 3. Tasks with attributive judgments.
Lesson 1.

Task A: "Find the answer." For example: “On the wall with colored crayons they wrote the words: case, cent, debt. Blue and white words have the same first letter, while white and red words have the second. What is the word blue? ”
a) case, b) cent, c) it is not known which, d) debt.

Task B: "Check the answer." For example: “One student solved the problem:“ Three words were written in colored pencils on the page: folk, lark, part. The green and yellow words have the same fourth letter, the brown and yellow words have the third. What is the word brown? ” The student replied: “Part.”
a) the answer is correct, b) the answer is incorrect

Group 4. Tasks with relational judgments.
Lesson 1.
Task A: "Find the answer." For example: “Klava, Vera and Lena live in the same house. In 10 years, Klava will be 6 years older than Lena now. Vera 3 years ago was 4 years younger than Klava now. Which of the girls is younger? ”
a) Lena, b) it is not known who, c) Vera, d) Klava

Task B: "Check the answer." For example: “One student solved the problem:“Zina, Lisa and Marina last year graduated from school. In 5 years, Lisa will be 6 years older than Zina now. Zina 2 years ago was 2 years younger than Marina now. Which of the girls is the oldest? ” The student answered: "Lisa."
a) the answer is correct, b) the answer is incorrect

Group 5. Tasks with attributive judgments.
Lesson 1.
Task A: "Find the answer." For example: “Katya, Lisa and Lena sent letters: someone - to Kiev, someone - to Moscow, someone - to Minsk. In January, the letter was either from Lena, or to Moscow. In February, the letter was either to Moscow, or from Katya. In March, the letter was either from Lena, or to Kiev. Who were the letters to Minsk from? ”
a) from Lena, b) it is not known from whom, c) from Katya, d) from Lisa.

Task B: "Check the answer." For example: “Kolya solved the problem:“ Vasya, Zhenya and Vitya went in for sports: some played hockey, some played tennis, and

some played volleyball. In the fall, there were training sessions either with hockey players or with Vasya. In the spring, there were training sessions either with Zhenya or with hockey players. What kind of sport did Vitya do? ” Kolya replied: “Vitya played tennis.”
a) the answer is correct, b) the answer is incorrect

Group 6. Tasks with relational judgments.
Lesson 1.
Task A: "Find the answer." For example: “Three words were written in blue, green and red:

SEA
LAKE RIVER

The blue word is to the left of the red. The red word is below the green. What paint did the word LAKE write? ”
a) blue, b) it is not known which, c) green, d) red.

Task B: "Check the answer." For example: “Natasha solved the problem:“ They wrote three numbers: one with a pencil, one with a pen, one with a felt-tip pen:

KASHA ROCKET
VASE

The word written in pencil is above the word written in pen. The word written with a felt-tip pen, to the right of the word written with a pen. What words are written in pencil? ” Natasha replied: “Rocket.”
a) the answer is correct, b) the answer is incorrect

Group 7. Tasks with attributive judgments.
Lesson 1.
Task A: "Find the answer." For example: “Alik and Borya made up words from cubes with letters. First, Alik composed the word DON. Then he rearranged the cubes and got the word NOD. Borya first composed the word BOX, and then rearranged the cubes in the same way as Alik. What happened to Borya? ”
a) BXO, b) it is not known that, c) XOB, d) XBO.

Task B: "Check the answer." For example: “Petya solved the problem:“ Nina and Klava made numbers from cubes with numbers. First, Nina made up the number

9762. Then she rearranged the cubes and got the number 7926. Klava first made up the number 4385, and then rearranged the cubes in the same way as Nina. What happened to Klava? ” Petya answered: "3458."
a) the answer is correct, b) the answer is incorrect

Group 8. Tasks with relational judgments.
Lesson 1.
Task A: "Find the answer." For example: “Alik and Borya are tourists. They went on a campaign at the same time: Alik from Moscow to Petersburg, Borya – from Petersburg to Moscow. Three days later, it turned out that Alik was closer to Moscow than Borya to St. Petersburg. Which of the boys was going faster?
a) it is not known who b) Borya c) Alik d) they walked equally fast

Task B: "Check the answer." For example: “Katya solved the problem:“ Natasha and Galya were engaged in motorsport. They left at the same time: Galya from Bryansk to Saratov, Natasha – from Saratov to Bryansk. After 4 hours, Natasha was farther from Bryansk than Galya from Saratov. Who drove slower? ” Kataya replied: "Galya."
a) the answer is correct, b) the answer is incorrect

In the first lesson of each group, children solved the problems of the standard structure, where it was required to find an answer to the proposed conditions and question. In this case, it was required to complete tasks of two types: A and B. When completing task A, the student should have found the answer. When completing assignment B, the student should check the proposed solution. The meaning of such a task for improving reasoning is that by finding out whether the answer was right or wrong, the student has the opportunity to understand the solution of the problem "from the outside." This creates favorable conditions for the formation of more accurate ideas about the nature of the correlation of judgments in reasoning.

In each group, in the second lesson, it was necessary to find a question for the proposed conditions, in the third - to find a part of the problem condition on the basis of the given question and another part of the condition, in the fourth - to find (taking into account this part of the condition and the question) such a variant of the other part of the condition, so that the answer to the task changes.

2.3. Educational activities

Classes under the program "Reasoning 1" consisted of three episodes. In the opening episode (a quarter of an hour long), the class facilitator shows the children different methods for dealing with a problem of the type intended for this lesson. Together with the children, the possible goals of search actions in tasks of this type and the correct and incorrect ways of obtaining conclusions based on the proposed judgments are discussed.

In the middle episode (half an hour long), children solve 12-14 problems on their own. Here, opportunities are created for the implementation of the information mastered in the previous episode of the lesson.

In the final episode (lasting a quarter of an hour), the organizer of the lesson discusses with the children the results of independent work. At the same time, correct and incorrect solutions are analyzed in order to once again show the children how to analyze the content of tasks and how to draw consistent conclusions. It should be pointed out that the effectiveness of classes is based on the differences in the proposed tasks: with affirmative and negative statements, with a different number of statements, with additional statements, with the right and wrong solution “it is not known who”.

2.4. Diagnosing Reasoning Skills

Before and after the 32 sessions of the “Reasoning 1” program, a special session was organized, in which the students of the experimental and control groups were offered simple and complex crypto-arithmetic tasks. Their solution is to substitute numbers instead of letters, in particular: NG+G=NN can be replaced by 21+1=22.

In the first part of the lesson, the organizer (schoolmaster) discusses with the students the task T H + P = T T. At the same time, the rules are explained: 1) different letters must be replaced with different numbers, and the same letters with the same numbers; 2) after replacing letters with numbers, there should be a correct arithmetic example.

As a result of the discussion of the proposals of the students, one of the answer options is accepted: 41 + 3 = 44. After that, the task T H - H = TF is parsed. Students are specifically reminded that 0 is also a number and a solution is offered: 21 - 1 = 20. Then each student is given a form with two educational and eight main tasks.

Form

Training tasks

1. AB + A = AB 2. AB - A = AA.

Main goals

1. AB +AB = BC 2. AB + BA=AA 3. AB – BA= CA 4. AB – CA= CC

5. ABC 6. ABC 7. ABC 8. ABC 9. ABC 10. ABC 11. ABA 12. ABC

+AB+ СБ–AB – CA+CBA+ CDD– BCB–DAB

ABD AAAAAAAED BDB EAA CCC DDD

The solution to training problems was tested in the lesson with the children. Then the children were asked to go to the main tasks, the solution of which was not tested in the classroom.

It should be noted that the main tasks are divided in complexity into three groups: tasks with only two-digit numbers, - the first degree of difficulty: 1–4; tasks with three-digit and two-digit numbers, - the second degree of difficulty: 5 - 8; tasks with only three-digit numbers, the third degree of difficulty: 9 - 12. At the same time, we took into account that, as preliminary experiments showed, in each group there are two addition problems, respectively: 1 and 2, 5 and 6, 9 and 10, - cause less difficulties for children than two tasks for subtraction, respectively: 3 and 4, 7 and 8, 11 and 12.

When processing the results of solving cryptoarithmetic problems in the control and experimental groups, six subgroups of subjects were allocated. Children who solved one or two problems of the first degree of complexity, made up subgroup A, solved three or four problems of the first degree of difficulty - subgroup B, who solved all problems of the first degree of complexity and one or two problems of the second degree of complexity - subgroup C, who solved all problems of the first degree complexity and three or four problems of the second degree of complexity - the subgroup D, who solved all the problems of the first and second degree of complexity and one or two problems of the third degree of complexity - the subgroup E, who solved all the problems of the first and second degree of complexity and three or four problems of the third degree of complexity - subgroup F.

3. Results

3.1 Performance

Table 1

The number of students in subgroups A, B, C, D, E and F of the control (C) and experimental (E) groups (proportional to the total number of students in the control and experimental groups) who successfully solved a particular number of cryptoarithmetic problems in September and May.

Subgroups Subjects	September		May	
	Cgroup, n (%)	E group, n(%)	Cgroup, n(%)	E group, n(%)
SubgroupA	7 (5.9)	11 (9.0)	4 (3.4)	0 (0.0)
SubgroupB	16(13.7)	19 (15.6)	11 (9.4)	3 (2.4)
SubgroupC	31 (26.5)	32 (26.2)	33 (28.2)*	21 (17.2)*
SubgroupD	25 (21.4)	24 (19.7)	28 (23.9)	34 (27.9)
SubgroupE	20 (17.1)	19 (15.6)	22 (18.8)**	39 (32.0)**
SubgroupF	18 (15.4)	17 (13.9)	19 (16.3)	25 (20.5)

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

3.1.1.Characteristics of the results of the control group

The data presented in the table show that in two subgroups of the control group in May, compared with September, there were fewer children: in subgroup A - by 2.5%, in subgroup B - by 4.3%, and in four subgroups - more: in subgroup C - by 1.7%, in subgroup D - by 2.5%, in subgroup E - by 1.7%, in subgroup F - by 0.8%. These indicators indicate that the occupation of children only in school curricula did not have a significant impact on the success of re-solving cryptoarithmetic tasks in May.

The most noticeable change in May compared with September occurred when solving problems of the first degree of complexity: the total decrease in the number of subgroups A and B was 6.8%. This fact means that the number of children able to successfully solve problems only of the first degree of complexity has decreased.

Less noticeable changes occurred in the number of subgroups C, D, E and F: the total increase in the number of these four subgroups was 6.7%. This fact means that the number of children able to solve not only the tasks of the first degree of difficulty, but also of the second and third degree of complexity has slightly increased.

It is interesting to note that in September and May, the largest subgroup, subgroup C, was composed of children who were able to successfully solve, in addition to tasks of the first degree of difficulty, one or two tasks of the second degree of complexity - an analysis of the protocols for solving problems by children of this subgroup showed most often these were the tasks of adding three-digit numbers with double-digit ones.

3.1.2.Characteristics of the results of the experimental group

With regard to changes from September to May in the number of subgroups of the experimental group, the data in the table indicate the following.

First, as in the control group, the number of subgroups A and B decreased, respectively: by 9.0% and 7.0%, i.e. in the amount of 16.0%. It is important to note that the size of subgroup A in May was 0.0%. This means that there are no children left in the experimental group who can solve only one or two problems of the first degree of complexity - only 3 students (2.4%) remain who can successfully solve problems only of the first degree of complexity and incorrectly solve more complex problems.

Secondly, in comparison with the control group, where the number of subgroup C increased and amounted to 28.2%, in the experimental group, the number of subgroup C decreased and amounted to 17.2%, the difference in the indicated indices was statistically significant (at $p < 0.05$). In contrast to the noted changes in subgroup C, the number of subgroup D increases in both groups: in the control group it is less - by 2.5%, and in the experimental group it is more - by 8.2%.

Thus, in the experimental group, the number of children who successfully solved only one or two problems of the second degree of complexity by adding three-digit and two-digit numbers (subgroup C) decreased, and the number of children who successfully solved three or four problems of the second degree of complexity (subgroup D) increased.

Thirdly, in the control group, the largest number of children in September and May make up subgroup C, while changes occurred in the experimental group. In September (as in the control group), the largest number of children was subgroup C (tasks of the second degree of complexity for addition), and in May (unlike the control group), the largest number of children was already subgroup E (tasks of the third degree of addition).

Compared to the control group, where the number of subgroup E increased by 1.7% and amounted to 18.8% in May, in the experimental group the number of subgroup E increased by 16.4% and amounted to 32.0% in May, the difference is, 8% and 32.0% are statistically significant (at $p < 0.01$). The total number of children of subgroups E and F in the experimental and control groups also differ statistically significantly (at $p < 0.01$) - 52.4% and 35.0%, respectively.

3.1.3.Comparison of the results of the control and experimental groups

An analysis of the protocols for solving cryptoarithmetic problems by children of both groups in September and May showed that in May in the control group (in comparison with September) some of the children by the success of solving problems go only to the neighboring subgroup: from subgroup A to subgroup B, from subgroup B to group C and so on. This means that one part of the students, solving in September, for example, only problems of the second degree of complexity for addition, in May began to solve problems of the same degree of complexity, but also for subtraction, i.e. this part of the students moved from subgroup C to subgroup D, i.e. to the next one.

In the experimental group, the transition to the success of the solution in the neighboring subgroup is not always carried out. In particular, an analysis of the protocols shows that part of the students of subgroup C went to subgroup D, and part to subgroup E. This means that one part of the students, solving in September only problems of the second degree for addition, in May began to solve problems of the second degree and on subtraction. The other part of the students, also solving in September only problems of the second degree of addition, in May began to solve not only all problems of the second degree of complexity, but also problems of the third degree of complexity - addition.

Thus, the noted changes in the experimental group indicate a significant impact of classes on the program "Reasoning 1" and school programs on the success of solving cryptoarithmetic problems.

In general, the results presented in the table indicate the features of improving reasoning in children aged 10 years during one year of primary school. Data describing changes in solving search (crypto-arithmetic) problems at the end of the school year (relative to its beginning) show that classes in school programs make a significantly smaller contribution to improvement of reasoning than classes in school programs in conjunction with classes in the program "Reasoning 1", developed on non-educational material.

3.2 Qualitative changes in participants' thinking, behavior and attitudes

Observations during the lessons allowed us to note a number of changes in the behavior of children over 32 lessons.

First, children began to participate more actively in the preliminary discussion and come up with more options for solving problems. They ceased to be afraid of mistakes when they offered their options for solving problems, since in these cases the teacher did not evaluate the children and their proposals, but, together with the students, analyzed the effectiveness of each solution option.

Second, the attitude of children to classes has changed, especially for those who in September were able to solve only the easiest tasks. In the first four to six classes, they showed increased anxiety: they were afraid that they would not succeed. Gradually, they calmed down and began to participate in the discussion of tasks, proposing certain solutions.

When solving problems independently, the activities of these children were supported, especially in the first five to eight classes. The teacher reminded the features of the type of tasks being solved and indicated those elements of the conditions that need to be taken into account. Such children for some time could not independently solve problems with incomplete conditions, with missing questions, and also perform tasks where it was required to check ready-made solutions. Teacher helped to understand the fallacy of wrong choices.

Third, the activities of children who successfully completed all tasks in September were also supported. They usually quickly dealt with independent problem solving, and the teacher offered them creative tasks for compiling tasks similar to those solved.

Conversations with teachers revealed the influence of developing activities on the intellectual behavior of students. First, children began to reason more consistently and more accurately analyze the conditions of problems in mathematics lessons. Second, they began to come up with more examples of the application of grammar rules in the lessons of their native language. Third, in children there was an increase in activity in the discussion of educational material in the lessons of various educational subjects and a decrease in negative emotions when studying complex phenomena in the lessons of natural science. Fourth, students who completed all tasks in September, after two or three months of classes, were often asked to give them additional material to solve problems at home.

At the same time, teachers noted changes in their work. In particular, in mathematics lessons, they began to offer children more problems of an unusual structure: with an incomplete condition or an absent question. In addition, in different academic disciplines, they began to practice tasks to verify the ready-made solution to problems.

4. Discussion

The study confirmed the initial hypothesis: the intervention based on the program "Reasoning 1" including eight types of plot-logical tasks in four structural variants led to significant improvements in elementary school children's reasoning. The results are generally in line with other studies on mathematical and logical reasoning in elementary school children that show that interventions tend to have a positive impact on such skills (e.g., 22,30,19, 21). The present study demonstrated this trend in a new contingent of primary school students.

Within the framework of the activity theory [26, 12, 2, 6], activity outcomes may change depending on the actor, objects and artefacts of the activity, as well as the division of labor and community norms.

In the presented intervention, instructional materials (artefacts) and community norms were changed to create a more productive educational context for children. The tasks were structured as a series of small steps that allowed students to tackle logical problems incrementally. This might have motivated students to work through problems instead of giving up. Children were also scaffolded by the teacher who was encouraged to create a supportive, safe space for students to make mistakes and learn through trial and error as well as by curricular design decisions, such as chunking the tasks into smaller pieces and providing solutions for them to check their answers. The long-term nature of the intervention (September through May) provided enough time for children to adjust to changes in the environment, which might have contributed to the improvements in their reasoning. Discussions of tasks with the teacher and other participants also mediated students' activity and could have had a positive impact on students' development of deductive thinking.

The results of the study are an additional argument in favor of the position of L. S. Vygotsky [32] in his polemic with J. Piaget [23]. Considering the problem of the relationship of learning and development, L. S. Vygotsky argued: "... Therefore the only good kind of instruction is that which marches ahead of development and leads it ..." [32, p.188]. In our study, it was shown that teaching with the help of a teacher (i.e., within the framework of the zone of proximal development) and changing the artefacts and tools of mediation in the learning process contribute to a significantly more intensive (compared with the control group) improvement of reasoning.

One of the important problems of educational psychology is the intellectual enrichment of the educational environment of elementary schools: that children more solve mental problems. The study showed a possible direction of intellectual enrichment of the learning environment, which is associated with the inclusion of a course of non-academic content in the curriculum in primary school.

5. Study Limitations

The results obtained should be considered taking into account the following restrictions.
The first limitation is associated with the composition of students in the control and experimental groups. The results of solving cryptoarithmetic problems in September showed that in the control group 49.6% of the children were able to solve all the problems, and in the experimental group - 48.3%. It can be assumed that with a different composition of students, when all tasks could be solved by 40% or 30% of children in each group, the results of classes would be worse.

The second limitation is related to the composition of teachers. The experience in primary school of 10 teachers in the control and experimental groups was, on average, 15–20 years. It can be assumed that when conducting classes with teachers with less experience, for example, 3-5 years, improving the ability to reason in children of the experimental group would be less effective.

It should be noted also that the study did not take into account the possible assistance of parents: its content and form, its quantity and frequency. Although, according to teachers, parents were actively interested in the successes of their children and perhaps somehow helped.

6. Conclusions

6.1.Future directions

The results of the study made it possible to formulate a number of problems for further study.

Firstly, it is planned to carry out a similar study with children of 11 years old in order to more fully and more accurately characterize the influence of the program "Reasoning 1" on the improvement of reasoning among students in grade 5.

Secondly, it is necessary to find the optimal composition of the plot-logical tasks included in the program "Reasoning 1" for students of different classes, from the third to the sixth. In particular, the effectiveness of a different (thanin this study) quantity and content of types of plot-logical tasks is of research and practical interest.

Thirdly, it is necessary to evaluate the effectiveness for improving the reasoning of tasks related to the independent compilation of tasks by children, as well as tasks where it is necessary to check ready-made solutions to problems with an incomplete structure, when you need to find a question or part of a condition.

Fourth, it is required to find more effective options: a) the time relationships of the three parts of the lesson (mentioned above); b) the duration of a separate lesson (it may be possible to combine two lessons of 40-45 minutes each into one lesson with a short (15-20 minutes) break; c) the regularity of classes: not 4 lessons per month, as in this study, but 6 or 8 lessons.

Fifth, it is planned to make some changes in the composition and work of teachers: a) to involve teachers with little work experience in the classes; b) instruct teachers not only on the basis of texts, as in this study, but also mainly in the conditions of a seminar, where it will be possible to communicate with the author of the program: ask questions and listen to explanations.

6.2.Summary

The purpose of the study was to determine the effectiveness of a longitudinal intervention in improving reasoning in children of 10 years old.The results revealed that the intervention was significantly more successful in improving participants' reasoning compared to traditionalcurriculum. Our observations and conversations with the teachers also showed that throughout the intervention students became less anxious about engaging withlogical problems on mathematical and linguistic material and making mistakes, started reasoning in a more consistent manner, and felt motivated to take on additional deductive problems to solve at home. Overall, these results align with a broader contextof thinking in elementary school children and with the postulated of the activity theory, according to which changes in tools of mediation and community norms may lead to differential activity outcomes.

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