Ilkogretim Online - Elementary Education Online, 2020; 19 (1): pp. 324-332
http://ilkogretim-online.org.tr
doi:10.17051/ilkonline.2020.644570

Improving combinatorial actions in children of 9 years

Anatoly Zak, *Psychological Institute of Russian Academy of Education,* Russia, *anatoly.zak@rambler.ru*
ORCID: 0000-0002-5646-3990

Abstract: The aim of the study was to determine the conditions for the improving of combinatorial actions in children of 9 years old (3rd grade 9 years old elementary school students). The original «Combination-2» educational program may become a condition for improving combinatorial actions. It was supposed to establish such conditions. The program includes 30 types of non-standard tasks with extracurricular content. Each type of task had three structural versions of the tasks: find the answer, find the question, and find part of the initial conditions. Solving these problems requires combinatorial actions. The control group consisted of 91 children, the experimental group — of 96. These children participated in 30 group classes for 30 weeks (weekly, from September to May). The study showed that the "Combination-2" lessons contribute to the improving of combinatorial actions in children. In further studies, it is planned to determine the extent to which the "Combination-2" program contributes to the improving of combinatorial actions in children of 10 years old.

Keywords: Combinatorial actions, 9 years old children, program "Combination-2"

Received: 16.09.2019	Accepted: 26.11.2019	Published: 15.01.2020

INTRODUCTION

Analysis of combinatorial actions in elementary school

The improving of combinatorial actions in elementary school is necessary for the successful mastery of mathematics in high school. An analysis of studies devoted to the study of the peculiarities of solving combinatorial problems by younger schoolchildren allows us to identify several main areas.

The researchers studied the ideas of children of this age about the number (Palmér, & van Bommel, 2016) when solving this type of mathematical problem, especially the systematization and presentation of their solutions (Palmér, & van Bommel, 2018), options for finding the result, using pictographic and iconic representations of the content (for example, animals) in the context of tasks and the use of digital tools (van Bommel, & Palmér, 2017), features of application in solving systematization and duplication of actions combined with the use of the digital version of the proposed visual conditions (van Bommel, & Palmér, 2018). In general, the results of these studies show that the success of solving combinatorial problems in the studied age is associated with children's ideas about the number, systematization and the use of digital tools.

Another area of research is related to comparing the features of solving combinatorial problems by 7 and 5 years old children. It has been established (English, 1991) that children of 7 years old, in contrast to children of 5 years old, are able to find systematic strategies for solving combinatorial problems with two variable attributes. Based on experiments with 7 and 4–6 years old children (Poddiakov, 2011) it is shown that in older children, unlike younger ones, playing with non-standard designs of multidimensional objects contributes to the development of combinatorial skills to a greater extent.

The third area of research is the study of the capabilities of children 7–12 years old in solving combinatorial problems. It was established (Krpec, 2014) that children of 7 years, based on an analysis of the sorting of various objects (drawings, letters, pieces of dominoes, numbers), are able to find various successful strategies for combining these objects. Found (Maher, &

Yankelewitz, 2011) that 7 and 8 years old children can structure the solution of simple combinatorial problems based on their use of informative representations. It is shown (English, 1993) that children 7 and 8 years old can find successful strategies for solving combinatorial problems with three changing attributes. It should be noted that in a later work (English, 2005), this author, summing up the results of previous studies (English, 1991, 1993), shows that the complexity of combinatorial problems solved by children is associated with cognitive abilities in younger students. The same conclusion is made as a result of experiments with 8–11 years old children (White, 1984): the success of solving combinatorial problems of varying complexity is associated with the level of intelligence development, determined by the results of solving the well-known Piagetian problems (Inhelder, & Piaget, 1969) to preserve the quantity.

The fourth area of research is related to the study of strategies and methods for solving combinatorial problems by children. The main methods for successfully solving different types of combinatorial problems by 10 to 11 years of age children are characterized (Břehovský, & Příhonská, 2017, 2018) and it is shown that the use of systematic recording is most effective when students create possible groups of elements using reasoning. It was noted (Herzog, Ehlert, & Fritz, 2017) that not all 3rd grade students can find a solution to combinatorial problems on their own and that the representations used by students do not significantly affect the achievement of the right solution, and the use of strategies to find the result has the greatest impact. Characterized by (Maher, & Yankelewitz, 2011) methods for solving pupils of grades 2 and 3 of combinatorial problems associated with the calculation of possible options for combinations of the proposed elements in accordance with certain requirements. When studying the relationship between schemes and intuition (Fischbein, & Grossman, 1997) on the material for solving combinatorial problems of various kinds (permutation, arrangement with and without substitution, combinations), it was found that even children of 6 years can solve combinatorial tasks not only through reasoning, but also intuitively and that intuitive guesses implicitly rely on correct and incorrect schemes. The latter fact allowed the authors to argue that it is necessary to use the correct schemes for solving particular problems in order to formulate correct intuitive guesses in children.

A special study of search strategies for solving combinatorial problems by younger schoolchildren (Höveler, 2016, 2017) showed that children use three main strategies to count the number of possible combinations — multiplicative, additive and compensatory — that reflect the traditional principles of combinatorial counting. The process of solving combinatorial problems (Hidayati, Sa'dijah, & Qohar, 2019) made it possible to identify the main four stages: identification (characterization of the combinatorial problem), selection of the object of combination, conclusion (determination of the type of combination), and reflection (comparison of the contents of the previous stages).

The fifth area of research is associated with various kinds of interventions in the learning process of solving combinatorial problems. The study (Krekić-Pinter et al., 2015) of the possibilities of mastering in elementary school methods for solving combinatorial problems based on the original creative pedagogical strategy, implemented by methodological transformation of combinatorial elements in the initial sections of mathematics, showed that with the help of this strategy more significant effects are achieved in comparison with the existing low level of solving combinatorial problems and that the application of this strategy can significantly affect the quality of the initial on teaching mathematics and the intellectual development of children. A study (Temnikova, 2018) of teaching pupils of grades 1 to 4 to solve combinatorial problems made it possible to establish that through the use of a combination of different strategies in the course associated with the permutation of elements, children develop skills to implement a combination of different approaches. Consideration of the impact of cooperation on solving combinatorial problems (Eizenberg, & Zaslavsky, 2003) led to the discovery of the relationship of cooperation, control, and successful problem solving, which is characterized by m, that cooperation leads to higher degrees of control, which, in turn, leads to more correct decisions.

Study Summary

The content of the studies examined allows us to note that most researchers use educational material. It should be noted that extra-curricular materials can be used to improve combinatorial actions. This material creates favorable conditions for the acquisition of combinatorial actions, since knowledge of the curriculum does not determine the success of research operations (as opposed to educational material). Children with insufficient performance are more confident than in solving academic problems, since this new experience is not spoiled by failure.

The aim of the study was to determine the conditions for the improving of combinatorial cognitive actions in 9-year-old children (third grade in Russian schools). Hypothesis: 30 lessons of the "Combination-2" program serve as a condition for this improvement program. This assumption is based on the results of preliminary experiments. In these experiments, 18 children of 9 years old solved the tasks of the "Combination-2" program in 12 lessons (two per week). It has been established that such problems contribute to the improving of combinatorial actions (Zak, 2004).

The program includes 30 types of non-mathematical combinatorial problems of categories: comparative, spatial and route. The solution of comparative problems is associated with the search for combinations of signs in the compared objects, the solution of spatial problems is associated with the search for combinations of actions to convert one location of objects to another, the solution of route problems is associated with the search for combinations of imaginary movements of characters on the playing field.

The study consisted of three stages. At the first stage, two groups of students participate (control group — 91 children, experimental group — 96), solving research problems to determine the degree of improvement of combinatorial cognitive actions. At the second stage, 32 lessons of the "Combination-2" program were conducted in the experimental group (one lesson per week). At the third stage, children from both groups again solve the research problem.

METHODS

Participants and data demonstration tools

The study involved a total of 187 children (91 — control group, 96 — experimental) aged 8 years 7 months to 9 years 4 months (mean =9.05; Standard deviation =2.46). There were 37 boys and 54 girls in the control group, and 38 boys and 58 girls in the experimental group, respectively. Children were not specifically selected to participate in the experiment. The subjects were ordinary students 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 second school.

To calculate the results that demonstrate the dynamics in the development of children, the Fisher test was used. This special criterion is to compare the difference between two variation series. The following formula was used (1):

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

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. The larger the value of φ*, the more likely that the differences are significant.

Educational activities

Classes in the "Combination-2" program included three periods. In the first period (about 15 minutes), the teacher and children consider methods for solving the type of tasks intended for this lesson. It is required that the students, firstly, understand what is sought for consists in the tasks of the type that are offered in this lesson, and secondly, what needs to be done to find the desired. The teacher tells the students how to disassemble the tasks, how to organize the search for what is sought, and how to control their actions when solving problems.

In the second period (about 30 minutes), time is given for an independent solution of 12 to 15 tasks. Here, children have the opportunity to use the information to find what they were told by the teacher in the first stage.

In the third period (about 15 minutes), the teacher checks the problems independently solved by the children. At the same time, he pays special attention to incorrect results in order to once again inform children about how to understand the conditions of tasks and how to act in order to find what they are looking for. Considering the features of the organization of developing classes, it is necessary to clarify the following. As can be seen from the diagnosis of children in September, among children in each of the four classes that make up the experimental group.

Three subgroups A, B, and C were distinguished. Accordingly, in each lesson, the experimenter proposed three types of forms with problems (comparative problems, spatial problems, and route problems). For subgroup A, the forms contained the simplest variants of problems of the corresponding type, for subgroup B, more complex variants, for subgroup C, the most complex variants of problems. After each lesson, the experimenter, along with the teacher, analyzed the results of solving problems by each student in subgroups A, B, and C and developed recommendations on the features of helping students of different subgroups with difficulties. The results of solving problems by each student in each lesson were recorded in a summary table for each class. This made it possible to compare the results of each student in different classes and compare the results of all students in one lesson.

The “Combination-2” program

The “Combination-2” program is designed to conduct 30 lessons based on 30 types of non-standard tasks with extra-curricular content: 10 comparisons of geometric figures (comparative problems), 10 spatial problems, and 10 tasks related to movement according to certain rules (route problems). These comparative problems, spatial problems and route problems contribute to the improving of combinatorial cognitive actions. At each lesson, children solve problems of the same type.

Table 1. *List of “Combination-2” lessons*

Type of task	Number of lesson (type of lesson)
Comparative	1 (1), 4 (2), 7 (3), 10 (3), 13 (6), 16 (7), 19 (8), 22 (7), 25 (11), 28 (12)
Spatial	2 (1), 5 (2), 8 (3), 11 (5), 14 (4), 17 (5), 20 (6), 23 (10), 26 (8), 29 (9)
Problems with the route	3 (1), 6 (2), 9 (4), 12 (4), 15 (5), 18 (6), 21 (9), 24 (7), 27 (8), 30 (10)

RESULTS

The description of the “Combination-2” tasks and their solutions

There is an example of “*Comparative problems*” task for comparing geometric figures with attributes (Figure 1):

“Look at the Figures 1–7. Figures 2, 5, 6 have one identical attribute. What are the three figures — 2, 3, 5; 1, 4, 6 or 5, 6, 7 have the same number of identical attributes, such as 2, 5, 6 figures?"

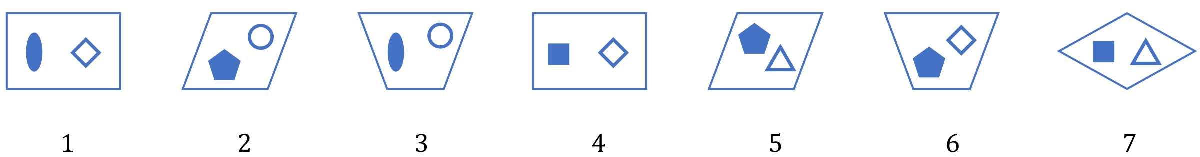

FIGURE 1. *Geometric figures with attributes*

There is an example of “*Spatial issues*” problems with special rules and solutions:

“How can the position of letters | N |___| G | change in two moves to get the next arrangement | G | N |_|?”

Rule: one movement is the movement of any letter in a free place.

Solutions:

- | N |_| G | — |_| N | G |;
- |_| N | G | — | G | N |_| or in total | N |_| G | — |_| N | G | — | G | N |_|:

on the 1^{st} move, the letter “N” moves to free space, on the 2^{nd} move — the letter “G” moves.

There is an example of “Problems with the route” tasks related to moving imaginary characters according to certain rules (Figure 2):

“What two steps did the ant take to get from 11 to 18?”

Rules:

- “Ant”, an imaginary character, moves by letters in the square cells;
- the characteristics of his movements are:
  (a) it steps directly, that is, into a neighboring cell vertically (for example, from cell 13 to cell 8 or cell 18) or horizontally (for example, from cell 13 to 14 or 12);
  (b) it goes obliquely, that is, diagonally (for example, from 13 to 7, 9, 19 or 17);
- the Ant cannot take two identical steps (two straight steps or two inclined steps) in a row.

Solution: 11 ... 12 ... 18.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

FIGURE 2. *Game field 1*

Diagnosing combinatorial actions

Before and after 30 lessons, group diagnostics was performed. Children were offered combinatorial tasks related to finding combinations of permutations between two digits on the playing Game field 2 (Figure 3).

First, the teacher told the children that at the tops of the eight squares there are round houses where numbers live. Lines between circles are roads that lead from one digit to another.

Then the teacher wrote on the board the condition for a simple combinatorial problem: (4— ? — 2) and said: “Do you need to find out which two roads can lead you from the digit 4 to 2?” Then he analyzed the solution to the problem with students.

After discussion, both versions of the solution were recorded:

(4 — 5 — 2) and (4 — 1 — 5).

Then the children were offered two more complex combinatorial problems, in which it was necessary to find all combinations of three roads between two digits:

1. 2 — ? — ? — 8
2. 6 — ? — ? — 4

Ten minutes were allotted for each problem.

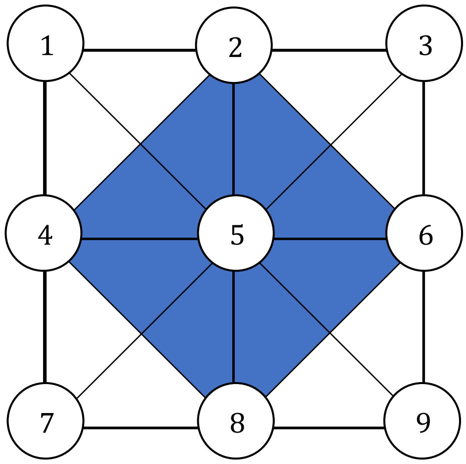

FIGURE 3. *Game field 2*

When interpreting the results of solving the problem, it was taken into account that the choice of the subsequent combination with respect to the previous one can be random or sequential. In the first case, pairs of neighboring combinations did not have a common component, i.e., (2 — 1 — 4 — 8) or (2 — 5 — 6 — 8). In the latter case, the choice of the subsequent combination included a component that she shared with the previous one, that is: (2— 1 — 4 — 8) or (2 — 1 — 5 — 8).

If the choice of each subsequent combination of roads was random, the strategy was considered chaotic. If the choice was extremely consistent, such a strategy was considered systematic. In this case, there was a maximum number (six) of adjacent pairs of combinations with a common component.

If random and consistent choices were made in the process of solving the problem, such a strategy would be considered mixed. A mixed strategy can contain from one to five consecutive options. This allows you to identify five levels of sequence in the implementation of a mixed strategy.

Characteristics of the improving of combinatorial actions in children of experimental and control groups

Processing the results of problem solving for both tasks made it possible to distinguish three subgroups of subjects in the control and experimental groups. Children of subgroup A implemented a chaotic strategy in solving both problems, children of subgroup B solved the first problem with a chaotic strategy, the second with a mixed strategy, children of subgroup C implemented a mixed strategy in solving both problems. There were no children who would use a systemic strategy among the subjects of our study. To determine the significance of the differences, the Fisher φ* criterion was used. Students in the control (CG) and experimental (EG) groups who decided on the basis of a random strategy two problems (subgroup A) and one problem (subgroup B) and those who solved both problems using a mixed strategy (subgroup C) in September (Table 2) and May (Table 3).

Table 2. *Characteristics of the development of combinatorial skills in children in September, n (%)*

Subgroups	A	B	C
CG	44 (48.35%)	24 (26.37%)	23 (25.28%)
EG	49 (51.04%)	24 (25.00%)	23 (23.96%)

Table 3. *Characteristics of the development of combinatorial skills in children in May, n (%)*

Subgroups	A	B	C
CG	36 (39.56%)**	28 (30.77%)	27 (29.67%)*
EG	16 (18.75%)**	35 (36.46%)	43 (44.79%)*

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

According to Table 2, the results demonstrated by children in the control and experimental groups who used random and mixed strategies did not differ significantly. The difference in sizes between subgroups A in CG and EG was 2.69%, in subgroups B — 1.37%, in subgroups C — 1.31%.

In May (Table 3), the difference in the sizes of the subgroups changed and became statistically significant for subgroups A and C: 21.81% ($p < 0.01$) and 15.18% ($p < 0.05$), respectively. The difference in subgroup B increased from 1.37% to 5.69%, but remained statistically insignificant. The study confirms the original hypothesis: the “Combination-2” program promotes the improving of combinatorial actions in children of 9 years old.

Experimental conditions

This result is explained by the features of the “Combination-2” program: extra-curricular content, research, differentiation by type of problem (spatial, comparative and route). The specific characteristics of the lesson are important: 30 one-hour lessons, which are held weekly for nine months. Each lesson consists of three parts — preliminary discussion, independent problem solving, and final discussion. Preliminary and final discussions teach the methods of analysis and problem solving, methods for monitoring and evaluating solutions, and contribute to the improving of combinatorial actions.

Study Limitations.

In September, an average of 48.35% of students applied only random strategies, 26.37% applied random and mixed strategies, and 25.27% applied only mixed strategies. With a different group structure, where the results were, i.e. 70%, 20%, and 10%, respectively, the effectiveness of the lesson could be lower.

Characteristics of teachers. Teaching experience averaged 15–20 years, whereas if it were 3–5 years, the improving of children in the experimental group would be less effective. There is no tracking of parental assistance, which, according to teachers, was present to varying degrees.

DISCUSSION and CONCLUSION

As noted, the aim of the study was to determine the conditions for improving combinatorial actions in children of 9 years. As a result of the study, it was found that the author's program “Combination-2” (30 types of various non-educational tasks) really acts as a necessary condition for achieving this goal.

The new knowledge obtained in the study about the conditions for improving combinatorial actions broadens and precise the ideas of developmental psychology about the intellectual development possibilities of younger schoolchildren.

The results of our study show that, in accordance with the concept of Piaget (Inhelder, & Piaget, 1969) on the specific operational stage of the development of intelligence in children 7–11 years old, children 9 years old are able to use not only chaotic strategies, but also mixed ones to solve combinatorial problems, related to understanding the relationship of subsequent actions with previous ones. In addition, the data obtained clarifies the concept of the famous Russian psychologist Davydov (2008) on the development of theoretical thinking in younger schoolchildren, since it was found that they are able to generalize the method of solving not only logical problems, but also combinatorial ones, when mixed strategies were not used to solve only the first, but also the second diagnostic task.

At the same time, the research results confirm the research data (English, 2005; White, 1984) on the relationship between the success of solving combinatorial problems and the level of mental development. We found such a relationship when analyzing the solution of comparative, spatial and route problems at 30 lessons by students of subgroup C of the experimental group. In all classes, these students successfully solved all problems, thereby demonstrating a high level of mental development.

Our study also confirmed the research data (Herzog, Ehlert, & Fritz, 2017) on the role of strategies and on the structure of search actions (Maher, & Yankelewitz, 2010) in solving combinatorial problems by younger schoolchildren.

It should be noted that in contrast to intervention studies related to improving the solution of combinatorial problems by teaching younger students on mathematical material (Temnikova, 2018), our study shows that the noted improvement can be achieved when solving problems on non-teaching material. Based on the study, it can be assumed that the established effectiveness of the "Combination-2" program will make it possible to develop programs for intellectual enrichment of the educational environment of elementary schools on non-teaching material.

According to teachers, the development of classes under the "Combination-2" program has led to positive changes both in their activities and in the behavior of students. Teachers began to apply more problems with incomplete conditions or missing questions and more often offer children to complete tasks similar to those that were solved (Zak, 2016). Children began to discuss issues more actively in mathematics and come up with more examples illustrating the rules of grammar.

At the next stages of our work to determine the conditions for improving combinatorial actions in younger students, it is planned to conduct a similar study with 8 and 10 years old children. This will allow a more complete and accurate assessment of the impact of the "Combination-2" program on the development of the combinatorial actions of children. Based on the obtained data, it is planned to develop a comprehensive program for teaching the thinking of primary school students, in which the "Combination-2" program will serve as propaedeutic for the development of critical and creative thinking.

REFERENCES

Břehovský, J., Příhonská, J. (2017). Combinatorial problems of mathematics for elementary school. 16th Conference of Applied Mathematics. *Applimat. Journal of Applied Mathematics and Engineerings,* 206-214.

Břehovský, J., Příhonská, J. (2018). The ability of primary school pupils to solve combinatorial tasks. In *17th Conference on Applied Mathematics. Source: Aplimat* (pp. 127-136). 13 September 2019 retrieved from http://evlm.stuba.sk/APLIMAT2018/proceedings/Papers/0127_Brehovsky_Prihonska.pdf

Davydov V. V. (2008). *Lekcii po obshhej psikhologii* [in Russian: Lectures in General Psychology]. Moscow: Academia.

Eizenberg, M. M., & Zaslavsky, O. (2003). Cooperative problem solving in combinatorics: the inter-relations between control processes and successful solutions. *The Journal of Mathematical Behavior, 22*(4), 389-403. https://doi.org/10.1016/j.jmathb.2003.09.001

English, L. D. (1991). Young children's combinatoric strategies. *Educational studies in Mathematics, 22*(5), 451-474. https://doi.org/10.1007/BF00367908

English, L. D. (1993). Children's strategies for solving two-and three-dimensional combinatorial problems. *Journal for research in Mathematics Education,* 255-273. https://doi.org/10.2307/749347

English, L. D. (2005). Combinatorics and the development of children's combinatorial reasoning. In *Exploring probability in school* (pp. 121-141). Springer, Boston, MA. https://doi.org/10.1007/0-387-24530-8_6

Fischbein, E., & Grossman, A. (1997). Schemata and intuitions in combinatorial reasoning. *Educational studies in Mathematics, 34*(1), 27-47.

Herzog, M., Ehlert, A., & Fritz, A. (2017). Kombinatorikaufgaben in der dritten Grundschulklasse. *Journal für Mathematik-Didaktik, 38*(2), 263-289. https://doi.org/10.1007/s13138-017-0118-8

Hidayati, Y. M., Sa'dijah, C., & Qohar, S. A. (2019). Combinatorial Thinking to Solve the Problems of Combinatorics in Selection Type. *International Journal of Learning, Teaching and Educational Research, 18*(2). https://doi.org/10.26803/ijlter.18.2.5

Höveler, K. (2016). Children's Combinatorial Counting Strategies and Their Relationship to Mathematical Counting Principles. In *Makalah disajikan dalam 13th International Congress on Mathematical Education Hamburg* (pp. 231-245). Dortmund: TU Dortmund. 1 September 2019 retrieved from https://www.mathematik.tu-dortmund.de/sites/karina-hoeveler/download/TSG17_PA_Hoeveler.pdf

Höveler, K. (2017). Children's combinatorial counting strategies and their relationship to conventional mathematical counting principles. In *Teaching and learning discrete mathematics Worldwide: Curriculum and research* (pp. 81-92). Springer, Cham. https://doi.org/10.1007/978-3-319-70308-4_6

Inhelder, B., & Piaget, J. (1969). *The psychology of the child.* New York: Basic Books.

Krekić-Pinter, V., Ivanović, J., Namestovski, Ž., & Major, L. (2015). Strategy and Methods for Solving Combinatorial Problems in Initial Instruction of Mathematics. *International Journal of Modern Education Research, 2*(6), 77-87. 30 August 2019 retrieved from http://article.aascit.org/file/pdf/9100785.pdf

Krpec, R. (2014). The Development of Combinatorial Skills of the Lower Primary School Pupils through Organizing the Sets of Elements. *ACTA MATHEM ATICA 17,* 103. 09 September 2019 retrieved from http://www.nmk.fpv.ukf.sk/2014/proceedings/13_krpec_fulltext.pdf

Maher C. A., Yankelewitz D. (2011). Representations as Tools for Building Arguments. In *Combinatorics and Reasoning. Representing, justifying and building isomorphisms* (pp. 17-25). Dordrecht, Springer Netherlands. https://doi.org/10.1007/978-94-007-0615-6_3

Palmér, H., & van Bommel, J. (2016). Exploring the role of representations when young children solve a combinatorial task. *ICT in mathematics education: the future and the realities,* 47. 08 September 2019 retrieved from http://ncm.gu.se/media/smdf/Published/No11_Madif10/047056_madif_001_palmer.pdf

Palmér, H., & van Bommel, J. (2018). The role of and connection between systematization and representation when young children work on a combinatorial task. *European Early Childhood Education Research Journal, 26*(4), 562-573

Poddiakov, A. N. (2011). Multivariable Objects for Stimulation of Young Children's Combinatorial Experimentation and Causal-Experimental Thought. *Psychology in Russia, 4,* 397. https://doi.org/10.11621/pir.2011.0027

Temnikova M. (2018). Combinatorial Mathematical Tasks in the Education in Mathematics for Grades 1-4. *European Scientific Journal, 2,* 46-55. https://doi.org/10.19044/esj.2018.c5p18

van Bommel, J., & Palmér, H. (2017). Paper or and digital: A study on combinatorics in preschool class. In *NORMA17 The Eighth Nordic Conference on Mathematics Education, Stockholm, 30 May–2 June 2017.* Svensk förening för MatematikDidaktisk Forskning-SMDF. 13 September 2019 retrieved from http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1181427&dswid=7604

van Bommel, J., & Palmér, H. (2018). Enhancing young children's understanding of a combinatorial task by using a duo of digital and physical artefacts. *Early years,* 1-14. https://doi.org/10.1080/09575146.2018.1501553

White, H. (1984). The development of combinatorial reasoning: the role of cognitive capacity. The journal of genetic psychology, 145(2), 185-193. https://doi.org/10.1080/00221325.1984.10532266

Zak A. (2004). *Myshlenie mladshego shkol'nika* [in Russian: Thinking of the younger school student]. St. Peterburg: sodeystvije.

Zak A. (2016). *Razvitie avtorskogo myshlenia u mladshih shkol'nikov* [in Russian: Development of author's thinking in younger schoolchildren]. Moscow: Biblio-Globus.