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A NEW METHODOLOGY BASED ON COMBINATORICS FOR DEVELOPING ALGORITHMIC THINKING

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Annotatsiya: This article presents a new methodology based on a combinatorial approach aimed at developing algorithmic thinking in students. The methodology enhances students' logical reasoning, ability to make choices, understand branching and recursive processes, and apply them by revealing the algorithmic structure of combinatorial problems, modeling them step-by-step, and converting them into algorithmic schemes. The methodology includes algorithmic models of classical concepts such as permutations, variations, and combinations, the structural stages of solving these problems, as well as a system of exercises that activate cognitive activity. This approach plays a crucial role in developing students' systematic thinking, skills in breaking down problems into parts, and creating effective solution algorithms. Additionally, the practical application, capabilities, encountered challenges, and ways to overcome them are also analyzed.

Keywords: Algorithmic thinking, combinatorics, permutation, variation, combination, methodology, recursion, branching, selection, educational technologies.

Introduction: In today's rapidly evolving digital era, algorithmic thinking is becoming an integral part of the educational process. Algorithmic thinking involves analyzing complex problems, breaking them down into a sequence of logical steps, developing a general solution strategy, and applying this strategy in various situations. Combinatorics plays a special role in developing these skills because combinatorial processes have a structure based on multiple options, branching, ordering, and repetition. Teaching combinatorial problems through an algorithmic approach not only imparts mathematical knowledge to students but also develops skills such as reasoning, step-by-step thinking, decision-making, and solution optimization. The inherently algorithmic nature of combinatorial processes served as the foundation for the development of this methodology. This article thoroughly examines the theoretical content, practical approaches, and application possibilities of a methodology aimed at developing algorithmic thinking based on combinatorics within the education system.

Main Part

1. The Importance of Algorithmic Thinking in the Learning Process

Algorithmic thinking is a crucial cognitive mechanism that shapes students' ability to break down mathematical processes into logical steps, understand them consistently, and apply them in practical situations. It serves not only as the foundation for mathematics but also for computer science, logic, technology, and engineering fields. Today, algorithmic thinking is recognized as one of the core competencies in global education systems.
Through algorithmic thinking, students can:
Divide complex tasks into smaller, manageable steps;
Compare various solution options and choose the most appropriate path;
Apply concepts such as branching, repetition, and conditional operators in practice;
Think about optimizing solutions;
Express their ideas while maintaining logical consistency.

Combinatorial problems provide an excellent foundation for algorithmic thinking because they inherently involve processes such as:
Arrangement of objects,
Selection,
Ordering,
Differentiation between limited and unlimited cases,
which naturally form algorithmic structures.
For example, the question "In how many ways can 3 books be arranged on a shelf?" inherently encourages students to think algorithmically by:

1. Selecting the books;
2. Determining the order;
3. Systematically counting all possible variants.

All these steps represent an inherently algorithmic sequence.

2. Algorithmic Models of Combinatorics

The main elements of combinatorics—permutation, variation, and combination—provide distinct algorithmic models that help develop students' structured, step-by-step thinking. Each model has its own mathematical formula, analytical content, and algorithmic essence.
2.1. Algorithmic Model of Permutation
Permutation is the arrangement of all elements in order. The number of permutations is:

$$P(n)=n!$$

This formula shapes two important ideas in the student:
The number of choices decreases at each step;
The process has a recursive nature.
For example, if there are 4 elements:

$$P(4)=4!=1\cdot 2\cdot 3\cdot 4=24$$

The algorithm to implement this situation is as follows:

1. Select one of the elements (4 different options).
2. Arrange the remaining 3 elements.
3. Add each arrangement to the final list.
4. Record all branches until the process is complete.

This process helps students form the concept of a "branching algorithm."
2.2. Variation algorithmic sequence
Variation — an ordered selection. Formula:

$$V(n,k)=\frac{n!}{(n-k)!}$$

This approach requires the following algorithmic sequence:
Aloop for the k elements to be selected;
Placing the selected elements in order;
Checking constraints at each step;
Recording the final solutions.
For example, arranging 3 elements chosen from 5:

$$V(5,3)=5\cdot 4\cdot 3=60$$

Through this process, the student finds the answer to the algorithmic question, "How many choices are there at this stage?"
2.3. Combination algorithmic model
Combination — a selection where order does not matter:

$$C(n,k)=\frac{n!}{k!(n-k)!}$$

From an algorithmic perspective, combinations reflect conditional constructions:
The principle of "selected or not selected";
Partitioning into sections;
A sequence of binary choices.
For example, selecting 2 elements from 6:

$$C(6,2)=15$$

This solution's algorithmic modeling is very convenient for students: for each element, there is a choice of “take” or “not take.”

3. Methodological approach based on combinatorial problems

The proposed methodology organizes the formation of algorithmic thinking in stages.
Stage 1. Understanding the problem
The objects, constraints, and selection possibilities of the problem are identified.
Stage 2. Determining the set of cases
Students look for the answer to the question, “How many different variants are possible?”
Stage 3. Creating an algorithmic scheme
At this stage, branching, repetition loops, and conditional operators are identified.
Stage 4. Step-by-step solution
The student explains each action based on the question, “Why exactly this step?”
Stage 5. Creating a general algorithm
For example, the general algorithm scheme for combinations:

1. Start
2. Select k elements from a set of n elements
3. Check each selection according to conditions
4. Add valid selections to the list
5. End

Stage 6. Reflection
The student evaluates their algorithm and analyzes possibilities for optimization.

4. Practical application

5. The methodology is very effective in the following areas:

Teaching combinatorics sections in school mathematics;
In higher education courses like “Discrete Mathematics” and “Algorithms”;
Working with recursive algorithms in programming basics;
Solving Olympiad problems;
Providing foundational knowledge in artificial intelligence and data structures.
Advantages of the methodology:
Forces students to think actively;
Makes the process visual and structured;
Integrates mathematical and algorithmic thinking.

5. Problems and opportunities

Problems:
Students may struggle to accept the recursive process;
Confusion may arise in tasks with many choices;
Difficulty in linking the algorithm with its mathematical expression.
Opportunities:
Significant growth in logical thinking;
High preparedness for programming;

Ability to generalize and analyze problems;
Full compatibility with STEM approaches.

Conclusion: The methodology for developing algorithmic thinking based on combinatorics plays an important role in fostering students' logical, systematic, and effective thinking skills. Teaching classical combinatorial processes such as permutations, variations, and combinations by breaking them down into algorithmic steps enhances not only mathematical skills but also general intellectual potential. The methodology ensures a harmony between theory and practice in the educational process and helps develop crucial skills in students such as programming, recursive thinking, and understanding branching structures. Broad application of this approach contributes to developing innovative thinking within the education system.

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