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The Role of Mathematics in Developing Cognitive Skills in Primary School Children

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Abstract:

The role of mathematics in the development of children's cognitive abilities is of paramount importance. Among school subjects, mathematics stands out as the one that most requires consistency and systematic thinking. Issues related to the teaching of mathematics have always attracted considerable attention, and it is only natural that they remain relevant today. The necessity of mathematical skills is beyond dispute, as students must acquire an interest in and appreciation for the subject from an early age. However, fostering such interest is by no means a simple task. Children, full of imagination and creative ideas, often find it challenging to shift their focus from the expressive nature of music and art classes to the discipline and rigor demanded by the exact sciences, requiring perseverance and willpower.

This paper focuses specifically on the primary level of education, since it is at this stage that the foundations of many essential cognitive skills are laid. The overarching aim of teaching mathematics in the primary grades is not limited to knowledge acquisition; rather, it involves developing students' thinking and reasoning skills, training them to recognize and interpret mathematical structures in everyday life, and cultivating habits of attention and concentration.

The present study is primarily based on pedagogical practice and draws upon classroom activities specifically designed to enhance cognitive skills. The empirical material presented here integrates both theoretical and practical components, which were developed, implemented, and tested with students.

The formation of elementary mathematical concepts constitutes a purposeful and organized process of transmitting and assimilating knowledge and methods. Mastery of such concepts is essential for children's intellectual development, as they significantly influence the formation of mental processes. Furthermore, mathematical knowledge must be gradually expanded and made more complex, taking into account both the age and cognitive development of the child.

The Main Part: The Role of Mathematics in Children's Cognitive Development

The process of teaching and learning mathematics engages all domains of cognition; therefore, a holistic approach is essential, emphasizing the integration of diverse activities that develop multiple skills simultaneously. The synthesis of perception, attention, memory, thinking, and—most importantly—imagination entails their combined use, enabling the enhancement of children's cognitive functions and making the learning process more engaging, enjoyable, and effective. Imagination supports students in generating and visualizing new ideas; attention enables them to focus on given tasks and their own creative contributions; memory ensures the processing and retention of information; and thinking plays a critical role in interpreting processed information and applying it pragmatically. Consequently, mathematics teachers should provide activities that integrate imagination, attention, memory, and reasoning, encouraging learners to create, imagine, retain, reflect, and critically discuss new ideas. In this process, verbal reasoning and language development also make significant contributions to overall growth.

Sensory development. The primary source of elementary mathematical concepts is the surrounding environment, with which children interact in everyday life. In teaching, a multimodal approach greatly enhances effectiveness, especially when hands-on methods are applied. Learning becomes more profound when multiple sensory channels are engaged: visual, tactile (e.g., recognizing the shape and size of objects by touch), and auditory. Gradually, this sensory experience accumulates, providing a foundation for the development of mathematical knowledge.

Development of thinking. Thinking, in conjunction with other cognitive functions, plays a critical role in understanding reality. In the formation of elementary mathematical concepts, all components of thought are engaged, as children are required to carry out various mental operations: analysis, synthesis, manipulation of abstract concepts, comparison, analogy, classification, and recognition of patterns.

Development of memory. Memory is a fundamental psychological process that encompasses the acquisition, storage, and retrieval of information. In mathematics learning, memory is actively involved and is crucial for effective functioning. Students must retain information, recall it when needed, and execute multi-step operations. For instance, in addition or multiplication tasks, students need to remember intermediate results while continuing to perform subsequent steps.

Development of attention. Attention is a prerequisite for perception, directing consciousness toward a particular object or activity and enabling clearer understanding. Motivation, which can be stimulated through engaging and learner-centered activities, plays an essential role in strengthening attention.

Development of imagination. Imagination allows individuals not only to reproduce perceived experiences but also to construct mental representations of new, unseen, or even non-existent objects. In mathematics, imaginative representations are generated through the mental construction of objects and play a central role in the development of abstract thinking.

Development of speech. Speech, as a cognitive act expressed through language, is also enriched by mathematics lessons. These classes expand students' vocabulary, promote verbal justification of mathematical operations, and enhance reasoning skills.

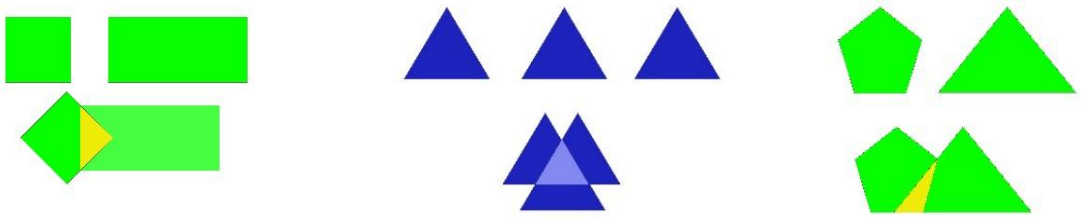
When discussing the interplay of cognitive skills, imagination, and mathematics, Jean Piaget's theory provides important insight. He argues that primary school children are capable of performing concrete logical operations based on the knowledge they already possess; however, they often struggle with abstract reasoning, generalization, and synthesis. For this reason, integrative, skills-based activities in mathematics—those that involve logical reasoning, decision-making, problem-solving, and imagination—gradually prepare students for abstract thought and ensure a smooth transition to higher stages of cognitive development.

In teaching, **visualization** is of particular significance, serving as one of the fundamental didactic principles. It involves direct observation of objects and phenomena through sensory modalities, making learning more accessible and reducing barriers. Both verbal resources (oral instructions, explanations) and visual or tactile resources (illustrations, models, hands-on activities) enhance effectiveness, an approach widely recognized as multimodal learning. Educational theorists such as Comenius, Rousseau, and Pestalozzi, as well as Georgian psychologist Dimitri Uznadze, have all emphasized the positive impact of sensory-based and visualized learning. As Comenius argued, the more sensory organs are involved in perception, the more vividly the object is grasped. Pestalozzi viewed visualization as the foundation of all knowledge, while Uznadze stressed that perceptual, sensory input is the necessary condition for the development of thought. Accordingly, the use of multimodal approaches in mathematics lessons—through diverse visual aids, practical tasks, educational games, tactile experiences, and real-life examples—significantly increases learning effectiveness and fosters the development of students' cognitive abilities.

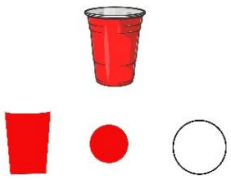
Let's consider specific exercises:

1. Activity: "Think, imagine and draw"

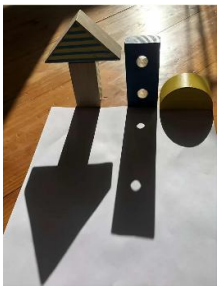
Students are required to place the given figures on top of each other in such a way that they partially intersect each other, and then draw the resulting figure in the intersection.



Students are tasked with drawing the geometric shapes they see when looking at a household item from different angles (front view, top view, and bottom view).



Students are given the task of drawing the geometric shapes (shadows) that are obtained by shining a lamp on a household item.



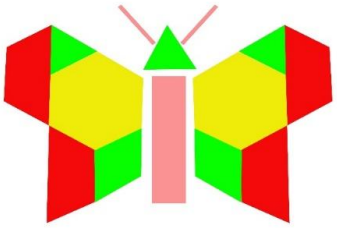
Activity 2: Identify the Cut-Out Print of the Figure

- In this activity, the teacher presents a variety of fruits and vegetables to the class.
- A student is randomly selected to cut one of the items without allowing the other students to see which one was chosen.
- Following the instructions, the student dips part of the cut-out in paint so that its print can be transferred onto a blank sheet of paper.
- The resulting print is then presented to the rest of the class.
- The next student to participate is the one who correctly identifies the fruit or vegetable based on the print.

This activity encourages observation, deduction, and engagement with shapes and textures.

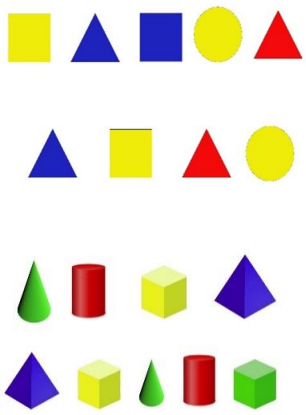
Activity 3: Identical Figures

Students are given a drawing on a sheet of paper or a spatial figure made from a white sheet of paper. They are instructed to identify all identical figures within the composition and color them using the same coloring material. This task helps students practice visual discrimination, pattern recognition, and systematic coloring while reinforcing the concept of identical shapes.



Activity 4: Discover the Change

In this exercise, the teacher shows the students geometric figures of various shapes and colors, naming each one aloud. Students close their eyes while the teacher makes a change in the arrangement, such as removing a figure or adding a new one. When the teacher signals, the students open their eyes and are tasked with identifying the figure that was added or removed. They must also describe its color and shape and then draw it. For example, the teacher may remove a blue square or add a green cube. This activity develops attention to detail, memory, and descriptive skills.



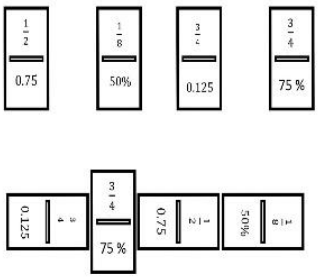
Activity 5: Anagrams of Mathematical Terms

Students work in groups to solve anagrams of mathematical terms. Their task is to identify the correct mathematical term and determine the minimum number of moves required to rearrange the letters to form the correct word, with any letter able to be inserted in any position. An electronic version of this game can be created using the Wordwall program, and the given lesson link provides an interactive version that can be played during class: https://wordwall.net/play/54908/437/216

This activity enhances problem-solving, collaboration, and familiarity with mathematical vocabulary.

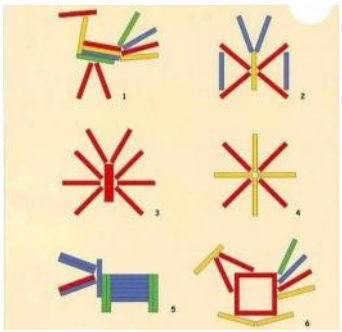
Activity 6: The Dominoes Board Game

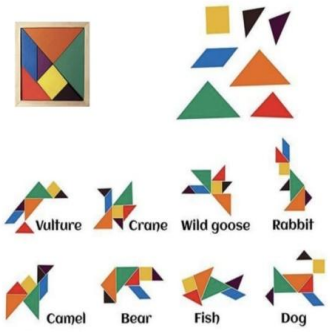
The board game “Dominoes” serves as an effective teaching tool to reinforce the concept of “form” in mathematics. Students work in small groups to arrange domino cards so that sections with correct correspondences are placed next to each other. The game helps students understand relationships between numbers, equivalent quantities, graphical representations and numbers, and information displayed in different forms. Through gameplay, students develop logical thinking, pattern recognition, and cooperative skills.

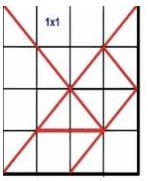


Activity 7: Discovering the Additivity of Length and Area Using the Heuristic Method

For length, students cut a rectangle into pieces of varying sizes and then reconstruct different shapes from these pieces. They measure each shape using a ruler and discover that the total length of the original rectangle equals the sum of the lengths of its pieces. For area, students cut a square into various pieces and create new figures from these parts. By observing the new figures, they realize that the area of each reconstructed figure equals the area of the original square. This hands-on activity promotes exploration, measurement skills, and understanding of additive properties in geometry.







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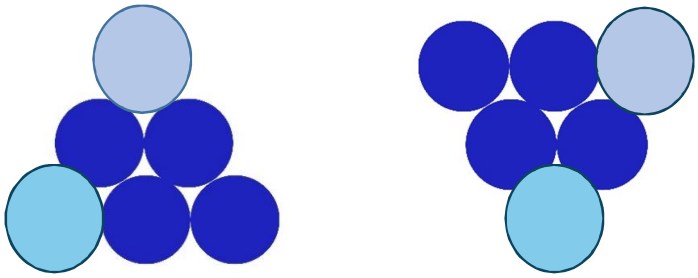
Activity 8: "Rearrange and Achieve the Correct Result"

This activity encourages students to experiment with spatial reasoning and logical thinking. On one task, various books of different sizes are arranged on shelves, with the rule that a smaller-volume book must be placed on top of a larger one. The student's goal is to rearrange the books so that all fit on a single shelf while following this rule.

In another task, students move two balls to form a downward-pointing triangle.



Similarly, in a third task, they move a matchstick to create a correct equality.

Students also engage in creating flat mathematical models by folding paper into different shapes, such as spatial figures or origami. Using straws or sticks, they can construct three-dimensional objects, helping them develop spatial visualization and manual dexterity.

Activity 9: Creative Mathematical Storytelling and Modeling

Students are tasked with creating models, applications, drawings, diagrams, stories, songs, illustrations, or animations based on mathematical conditions.

Example 1: one story might describe a night sky where two stars try to connect but are repelled by an invisible force. The “Little Prince” draws a magical line between them, creating a segment labeled AB. Other stars are then connected in pairs, triplets, or quadrilaterals, forming various geometric figures such as triangles, quadrilaterals, and pentagons.

Example 2 uses a playful poem to personify geometric shapes, celebrating their properties and symmetry: triangles, circles, squares, and pentagons “dance” and “sing” around the world.

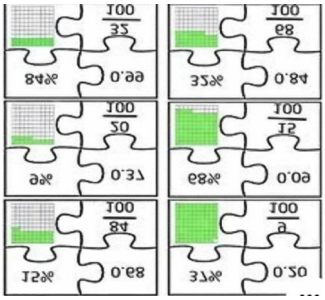
Cheerful shapes, we sing with delight,
Dancing around the world, spinning in light.
The triangle, firm and true, with three sharp points,
Precision in form, where artistry anoints.
The circle, smooth and curved, endless in its round,
Rolling downhill, no rival to be found.
The square, the king of symmetry, with four equal sides,
No scratch, no flaw, in its angles it prides.
The pentagon, versatile, with five sides to share,
Together we shape a world where every form has its place to care.
Cheerful shapes, we sing around you with glee,
What you see we are, bringing harmony for all to see.

Students choose narratives that inspire them and create performances using these ideas, such as puppet shows or role-playing games. Decorations and props incorporate mathematical elements, blending creativity with geometry.

Example 3: Interactive animations, like https://bit.ly/403M77Z, can further enhance the experience.

Activity 10: Mathematical Puzzles

Students are divided into small groups and tasked with assembling a disassembled flat figure or three-dimensional object. Puzzle pieces can be physical, such as wooden or plastic parts, or digital, where students use interactive programs with drag-and-drop functionality. These digital tools often allow 3D rotation and manipulation, enhancing spatial perception.



Teams aim to solve the puzzle as quickly as possible, but success is measured not only by speed but also by accuracy and teamwork. This activity reinforces problem-solving, collaboration, and geometric understanding in a hands-on, engaging way.

Activity 11: Culinary Math – Integrating Cooking into Mathematics Lessons

In this interdisciplinary lesson, the mathematics teacher guides students through a hands-on culinary activity, such as preparing healthy salads, while focusing on mathematical skills. Students work in small groups and begin by measuring ingredients, emphasizing accuracy in units of measurement. The teacher introduces mathematical concepts such as ratios, proportions, fractions, and percentages, and students calculate these values for their recipes. Next students represent their data visually by creating charts or tables to compare ingredient quantities or proportions. The mathematics teacher monitors students' calculations, problem-solving, and chart creation, providing guidance when errors occur and encouraging discussion about the mathematical relationships observed during cooking. This activity not only reinforces arithmetic, data handling, and reasoning but also cultivates teamwork, creativity, and engagement. By contextualizing mathematics in a real-life scenario, the lesson demonstrates the practical value of math, making learning meaningful, interactive, and enjoyable.

Conclusion: Mathematics plays a crucial role in the holistic development of children's cognitive abilities, particularly during the formative years of primary education. Beyond the acquisition of numerical skills, mathematics nurtures attention, memory, reasoning, imagination, spatial awareness, and language, creating a foundation for both academic success and practical problem-solving in everyday life. Through thoughtfully designed activities—ranging from hands-on manipulation of shapes and interactive games to creative storytelling and modeling—students engage multiple cognitive domains simultaneously, strengthening their intellectual flexibility and critical thinking.

The integration of sensory experiences, multimodal learning, and imaginative exploration ensures that mathematics lessons are not only rigorous but also engaging and meaningful. By fostering curiosity, persistence, and collaborative skills, such approaches prepare children to approach abstract concepts with confidence and to transfer logical thinking to diverse contexts. Ultimately, the deliberate and creative teaching of mathematics in primary education cultivates well-rounded cognitive development, equipping young learners with the mental tools necessary for lifelong learning and intellectual growth.

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