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Research Article

Mathematics: The Invisible Engine Behind Computational Thinking

Dr. Kishor Nikhare

Mathematics Teacher at Reliance Foundation School, Mouda, Nagpur, Maharashtra, India

Corresponding Author: *Dr. Kishor Nikhare

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Abstract

In the era of Artificial Intelligence (AI), data science, and digital innovation, Computational Thinking (CT) has emerged as a vital 21st-century skill. The National Education Policy (NEP) 2020 emphasizes the development of critical thinking, problem-solving, creativity, and digital literacy among school students. While coding and technology often receive significant attention in discussions on computational thinking, mathematics remains the invisible engine that powers these competencies. Mathematical thinking nurtures logical reasoning, pattern recognition, abstraction, and algorithmic problem-solving—the very pillars of computational thinking. For middle school learners (Classes VI–VIII), mathematics provides numerous opportunities to develop CT skills through inquiry-based learning, mathematical modelling, puzzles, data analysis, and real-life problem-solving. This article examines the relationship between mathematics and computational thinking in the context of NEP 2020 and highlights practical approaches to fostering future-ready learners equipped for the AI-driven world.

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INTRODUCTION

The world is experiencing unprecedented technological growth driven by Artificial Intelligence (AI), machine learning, robotics, and big data. As technology becomes an integral part of everyday life, education must evolve to equip students with the skills necessary to navigate and contribute to this changing landscape. Recognizing this need, the National Education Policy (NEP) 2020 advocates an educational framework that promotes critical thinking, creativity, innovation, and problem-solving rather than rote memorization.

Among the competencies identified as essential for future success, Computational Thinking (CT) occupies a central position. Computational thinking enables learners to approach complex problems systematically, develop logical solutions, and make informed decisions. While computational thinking is often associated with computer science and coding, its true foundation lies in mathematics. Mathematics quietly supports the development of computational habits of mind, making it the invisible engine behind computational thinking.

Understanding Computational Thinking

Computational Thinking is a structured approach to problem-solving that involves breaking down complex problems, identifying patterns, focusing on relevant information, and developing step-by-step solutions.

1. Decomposition

Decomposition involves breaking a large or complex problem into smaller, manageable parts so that it becomes easier to solve. In mathematics, students often use this skill while solving multi-step word problems. For example, a Class 6 student finding the total cost of notebooks and pens first calculates the cost of each item and then adds the amounts. By dividing the problem into smaller tasks, students can work systematically and avoid confusion.

2. Pattern Recognition

Pattern recognition is the ability to identify similarities, regularities, or trends in numbers, shapes, or situations. Mathematics provides numerous opportunities for students to discover and extend patterns. For example, Class 7 students exploring the sequence 2, 4, 8, 16, 32 recognize that each number is obtained by multiplying the previous number by 2. Such activities help learners predict future terms, make generalizations, and develop analytical thinking skills that are essential for computational thinking.

3. Abstraction

Abstraction involves focusing on important information while ignoring unnecessary details. In mathematics, students use abstraction when they represent real-life situations using symbols, variables, tables, or graphs. For example, a Class 8 student studying the relationship between the number of notebooks purchased and the total cost may express it as Cost = 40 × Number of Notebooks, rather than listing individual examples. This process helps learners identify general rules and understand underlying mathematical relationships.

4. Algorithmic Thinking

Algorithmic thinking refers to developing a logical sequence of steps to solve a problem. Mathematics encourages students to follow and create procedures for arriving at solutions. For example, when a Class 8 student solves a linear equation such as $2x + 5 = 17$, they follow a series of steps: subtract 5 from both sides and then divide by 2 to find the value of x. Similarly, constructing geometric figures using a ruler and compass requires following precise instructions in a particular order. Such experiences strengthen logical reasoning and systematic problem-solving abilities.

In middle school mathematics, these four dimensions of Computational Thinking are naturally embedded in activities such as solving word problems, exploring patterns, working with algebra, analyzing data, and performing geometric constructions, making mathematics the ideal foundation for developing future-ready learners.

These cognitive processes are not limited to computer programming; they are deeply embedded in mathematical thinking and classroom learning experiences.

Mathematics: The Invisible Engine

Students frequently encounter computational thinking without realizing it while learning mathematics. Every mathematical task demands logical reasoning, evaluation of relationships, identification of patterns, and strategic decision-making.

Consider the following examples:

Computational Thinking Component	Mathematical Application
Decomposition	Solving a multi-step word problem
Pattern Recognition	Identifying number sequences and geometric patterns
Abstraction	Representing situations using variables and equations
Algorithmic Thinking	Following procedures to solve equations or construct geometric figures

Through mathematics, learners develop mental models that help them analyze problems and generate solutions. These skills subsequently transfer to coding, engineering, data science, and AI-related fields.

NEP 2020: A Vision for Future-Ready Learners

NEP 2020 emphasizes a shift from content-based learning to competency-based education. The policy encourages educational practices that promote inquiry, experimentation, collaboration, and critical thinking.

The policy specifically recommends introducing:

- Coding and computational thinking from the middle school stage.
- Experiential and activity-based learning.
- Interdisciplinary learning experiences.
- Problem-solving and logical reasoning activities.
- Technology-integrated teaching and learning.

Mathematics naturally aligns with these goals. Through carefully designed classroom experiences, mathematics can become a powerful vehicle for developing computational thinking skills among students.

Developing Computational Thinking Through Middle School Mathematics

Pattern Exploration and Generalization

Topics such as number sequences, arithmetic patterns, divisibility rules, and algebraic relationships encourage students to identify regularities and make predictions. Activities involving the Fibonacci sequence, Pascal's Triangle, or tessellations enhance analytical thinking and curiosity.

Geometry and Spatial Reasoning

Geometry provides rich opportunities to develop computational thinking. Investigating symmetry, transformations, networks, and geometric constructions encourages students to observe patterns and think logically.

Data Handling and Statistics

Data collection, organization, tabulation, graphical representation, and interpretation develop students' ability to analyze information systematically. These skills form the foundation of AI and machine learning applications.

Algebraic Thinking

Algebra offers powerful opportunities for abstraction. Students learn to represent unknown quantities using variables, establish relationships, and formulate general rules. Such experiences lay the groundwork for computational problem-solving and programming logic.

Mathematical Modelling

Middle school students can engage in projects involving environmental issues, resource management, population growth, or school-based surveys. Mathematical modelling enables learners to connect classroom concepts with real-world situations while applying computational thinking processes.

Mathematics and Artificial Intelligence

Artificial Intelligence may appear highly sophisticated, but its foundations are rooted in mathematics. Algorithms, probability, statistics, logic, and pattern analysis drive AI systems.

Middle school students frequently interact with AI-powered technologies such as:

- Voice assistants
- Online recommendation systems
- Navigation applications
- Language translation tools
- Educational learning platforms

Understanding the mathematics behind these technologies helps students become informed users and future creators of technology. Mathematics enables learners to move beyond merely consuming digital tools to understanding how these tools function.

Classroom Strategies for Classes VI–VIII

Teachers can cultivate computational thinking through mathematics by:

- Using mathematical puzzles, riddles, and games.
- Encouraging multiple approaches to solving problems.
- Incorporating coding activities linked to mathematical concepts.
- Organizing STEM and mathematical modelling projects.
- Promoting collaborative problem-solving discussions.
- Integrating real-life contexts into mathematics learning.
- Encouraging students to explain and justify their reasoning.

Such strategies align with the pedagogical vision of NEP 2020 and foster deeper conceptual understanding.

Preparing Learners for the AI Era

The future workforce will require individuals who can think critically, solve unfamiliar problems, adapt to technological changes, and innovate responsibly. Mathematics education at the middle school level plays a vital role in nurturing these competencies.

When students engage in mathematical reasoning, they learn to:

- Think logically.
- Analyse information systematically.
- Make evidence-based decisions.
- Develop perseverance in solving challenging problems.
- Build confidence in handling complexity.

These abilities extend beyond the mathematics classroom and prepare students for lifelong learning.

CONCLUSION

As envisioned in NEP 2020, education must empower learners with the competencies required for an increasingly interconnected and technology-driven world. Computational Thinking has become a cornerstone skill for success in the AI era, and mathematics serves as its invisible engine. Through logical reasoning, pattern recognition, abstraction, and algorithmic problem-solving, mathematics provides the intellectual foundation upon which computational thinking is built.

For students of Classes VI–VIII, integrating computational thinking into mathematics education offers meaningful opportunities to transform learning from routine procedures to creative exploration. By nurturing computational thinkers through mathematics, schools can prepare a generation of

confident, innovative, and responsible citizens capable of shaping the future of India in the age of Artificial Intelligence.

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About the Author

Dr. Kishor Nikhare is a Mathematics Teacher at Reliance Foundation School, Mouda, Nagpur, Maharashtra, India. He is dedicated to mathematics education and focuses on developing students' conceptual understanding, analytical thinking, problem-solving abilities, and logical reasoning. His teaching approach emphasizes clarity, practical applications, academic excellence, and fostering a strong interest in mathematics.