

COGNITIVE DISCOURSES

INTERNATIONAL MULTIDISCIPLINARY JOURNAL

ISSN 2321-1075 ISSN 2347-5692

VOLUME 11

ISSUE 1

JULY 2023

cdimj.naspublishers.com

Published Since 2013

Integration of 21st-century skills: Problem-solving in Mathematics Curriculum

Deepthi. O.V.
Assistant Professor
SUM College of Teacher Education, India.

Abstract

Students need more than just traditional mathematical knowledge in the fast-changing modern world of the 21st century. In this knowledge-based, globalized, and technologized world, our living and interacting styles are changing. Therefore, we, especially the growing generation, should have to attain the competing skills to critically think, maintain a collaborative mindset, enable exemplary communication, and adapt to a more challenging life and work environment. These modern and newly important competing skills are collectively called 21st-century skills. Many international frameworks like OECD, ATCS, P21, and UNESCO have listed some 21st-century skills such as critical thinking, problem-solving, creativity, communication, media literacy, technological literacy, innovation, metacognition, leadership, collaboration, etc. All such organizations agree that these modern skills can be taught by teaching different subjects in a well-framed curriculum. Mathematics is a subject that includes numbers, angles, formulas, and finding the correct answer to difficult problems. So, the students can find solutions to each problem. Problem-solving skills help people arrive at an appropriate answer through components such as planned observation, critical thinking, creativity, communication and collaboration. This paper discusses the importance of the 21st-century skill Problem problem-solving, the idea behind problem-solving skills, the importance of developing problem-solving skills, strategies for integrating problem-solving skills, the role of the teacher in integrating problem-solving skills and challenges in the integration of Problem-solving skills in the Mathematics curriculum.

Keywords: 21st-century skills, problem-solving, mathematics curriculum, critical thinking, collaboration, communication, analytical thinking

Introduction

The competing skills developed through various stages of human life are needed to survive in a more challenging day-to-day life and work environment. Therefore, all over the world most of the educational systems currently focus on integrating competing skills, newly called 21st century skills in the Curriculum. As with all other subjects, Mathematics is also a platform where students can practice these skills. Integrating modern skills like problem-solving skills into the Mathematics curriculum is very significant in the technologically advanced and globalised world because it develops creativity, and enhances the capacity of critical thinking, communication and collaboration among the students. This leads us to a new approach that combines traditional mathematics concepts with innovative problem-solving techniques to develop these modern competencies. This approach not only enhances academic achievement but also prepares students to become creative thinkers ready to meet the dynamic challenges of the twenty-first century. The teachers have been facing some challenges in integrating these skills into lessons and assessing them. However, systematic and strategic techniques that are developed by many international frameworks and organizations enable the successful integration of modern skills into lessons and mold skilled generations.

The 21st -century skills

The term “21st-century skills” refers to the knowledge, abilities, habits, and characteristics that are critical to students’ success in the modern world when they proceed to higher education, employment, and family and social life. In general, students can use 21st-century skills throughout their lives in all academic subject areas as well as in educational, professional, and civic contexts. P21, an American organization founded in 2002 by business leaders, consultants, and educators, conceptualized a framework for 21st -century skills. They classified these skills mainly into three categories, such as

- Learning and innovation skills include competencies such as creativity and invention, communication and teamwork, critical thinking and problem-solving
- Information, media, and technology skills—Media literacy, Information literacy and information and Communication Technology literacy (ICT) are examples of digital literacy skills.
- Life and career skills: adaptability and flexibility, self-motivation and initiative, social and intercultural communication, productivity, and accountability are the sub-competencies of this skill. (learning, 2019)

These abilities are thought to be essential for people to prosper in the contemporary world, both in their personal and professional spheres.

The Idea Behind Problem-solving Skills

Problem-solving skills are essential to cutting through such situations when faced with crises in a child's daily life. Life skills can be acquired by the individual both inside and outside the classroom. In such situations, problem-solving is the most important skill that the teacher should impart to the child and develop by the student himself. The teachers were focused on attempting to clarify and define problem-solving approaches almost all the time in the 20th century. Still, some people believe that a set of machine-driven, systematic, and decontextualized skills is required for problem-solving as these skills are required for solving equations and mathematics puzzles. But actually, problem-solving skills are a mental process which involves critical thinking, decision - making and reflective thinking.

According to PISA (2012), "Problem-solving competency is an individual's capacity to engage in cognitive processing to understand and resolve problem situations where a method of solution is not immediately obvious. It includes the willingness to engage with such situations in

order to achieve one's potential as a constructive and reflective citizen." (TRIAL, 2010)

A problem is a non-routine state or condition for which there are no simple, regular solution approaches, in contrast to an easy task. Problem-solving therefore involves logical reasoning in order to process information in a way that may be used to solve the problem effectively and efficiently.

The Importance of Developing Problem-Solving Skills

Enhancing Critical Thinking

In the complicated and quickly changing world of today, critical thinking is an essential talent. It entails information analysis, argument evaluation, and well-informed decision-making. People who have developed their critical thinking abilities are better able to overcome obstacles, make wise decisions, and positively impact society.

Fostering Collaboration and Communication

To tackle complicated problems and come up with creative solutions, problem-solving requires collaboration and communication. To create a more comprehensive grasp of the issue at hand, effective collaboration entails bringing together a variety of viewpoints, specialities, and life experiences. It facilitates the integration of diverse methods, fosters critical thinking, and encourages the exchange of ideas.

Creativity and Innovation

In the subject of mathematics, creativity and innovation are essential abilities that propel advancement, discovery, and the creation of novel ideas and solutions. Mathematical creativity is thinking outside the box, making connections between seemingly unrelated ideas, and coming up with new concepts or methods. Mathematicians frequently have to come up with fresh approaches to issues, investigate different avenues, or develop original theories. Innovative approaches to

solving challenging mathematical problems can be developed with the use of creative thinking. (Lewis, 2023)

Integration of Problem-Solving Skills at Different Levels

A child must acquire different types of problem-solving skills at each stage of education. For example, for a person in primary education, the basic problem-solving skills are multiplication, division, addition, and subtraction. In the upper primary level, the student begins to use the basic problem-solving skills that he or she learned from the primary level to solve some daily life problems. Then, in the secondary levels, the child moves into higher levels of problem-solving skills. By the time that student reaches adulthood, he must have acquired thousands of problem-solving skills from inside and outside of the classroom that will contribute to the self-development and self-realization of an individual and healthy progress in society.

Pre-Primary Mathematics Curriculum

A teacher provides a problematic situation, for example,

Problem: "Three friends have 12 toys. How can they be divided equally?"

- Students can use different approaches, such as drawing pictures of the toys, grouping them into sets of 3, or counting to find that each friend should get 4 toys. This exercise teaches division, sharing, and problem-solving in a fun and interactive way.
- By incorporating these elements into the pre-primary math curriculum, young children can lay a solid foundation for 21st-century problem-solving skills while making learning fun and relatable.

Primary mathematics curriculum

- The teacher asks the children to work on "mathematical pattern recognition."

- Then the student should understand the problem by discussing it in the class. They should raise many questions to realise what we already know and what we have to find out.
- Understand the problem: Begin by reading the problem and discussing it as a class. "What do we know?" Ask the students questions such as "What are we trying to find?"
- Identify patterns and relationships: Encourage students to identify any patterns, relationships, or similarities in the problem. In our example, you can present a sequence of numbers using a hidden pattern.
- Brainstorming Solutions: Have students brainstorm multiple ways to approach the problem. It encourages creativity. For the pattern recognition problem, ask them how to find the next number in the sequence.
- Collaborative Learning: Encourage students to work in pairs or small groups to discuss their solutions and insights. It encourages cooperation.
- Present and discuss solutions: Students present their findings to the class. It builds communication skills.
- Reflect and revise: After discussing solutions, ask students if there are alternative approaches or if what they learned can be applied to other problems. This stage encourages critical thinking and self-evaluation.
- Evaluation: Assess students not only for the accuracy of their answers but also for their ability to articulate their problem-solving process and creativity in approaching the problem.

High School Mathematics Curriculum

Example: Real-World Geometry Problem

Problem: Your backyard is a rectangular area 10 m long and 6 m wide. You want to design a garden in this space while increasing the area of the garden. The garden should be divided into two parts: one for flowers and one for vegetables. What are the dimensions of each section for the maximum garden area?

- Break the problem into parts: Calculate the maximum area of the garden while keeping the length and width of each part constant.
- Use algebra to create an equation that represents the total garden area in terms of the width of each section.
- Find the critical points of the area function using calculus.
- Analyse the results and select measurements that maximize the garden area.

This example combines geometry, algebra, and calculus to encourage critical thinking and creativity in solving real-world problems.

The higher Secondary Mathematics Curriculum

Example: Scenario: Pupils need to plan their savings for retirement. They are given a certain amount to invest, and they have to decide between different investment options, taking into account factors like interest rates, time horizon, and risk tolerance.

Mathematical Concepts: Students apply exponential growth equations to compound interest and probability concepts to evaluate investment risks.

By following this approach, you can integrate 21st-century problem-solving skills into the math curriculum while addressing practical, real-world problems. This method not only enhances mathematical skills but also equips students with critical thinking, teamwork, and research skills.

Role of the Teacher in Integrating Problem-Solving Skills in The Mathematics Curriculum

- Encourage students to analyse a given problem from multiple angles and explore various approaches and solutions for that particular problem.
- Generate curiosity in given problems and create a mind to find their own solutions.
- Motivate the students to collaborate with others to find out the solution, and guide them to cooperate with peers and ensure teamwork.
- Adapt the individual needs and Caliber of each student. Let them follow unique learning styles and provide the instructions needed accordingly.
- Familiarise available modern technology and tools that are suitable for each lesson to solve mathematics problems.
- Provide constructive and timely feedback to refine their problem-solving techniques and keep moving on till a solution is found.

Challenges Facing the Integration of Problem-solving Skills in the Mathematics curriculum

Integrating 21st-century problem-solving skills into the math curriculum presents several challenges. They are:

- **Resistance to change:** Traditional teaching methods are resistant to integration, and teachers may be reluctant to move away from traditional approaches.
- **Curricular constraints:** Incorporating new skills into existing curriculum requirements can be challenging.
- **Teacher Training:** Many teachers may need additional training to effectively teach problem-solving skills.
- **Assessment Difficulties:** The traditional assessment method is being replaced by modern complex problem-solving skills.

- **Resource constraints:** The availability of technology and materials to support this integration may vary between schools.
- **Varying Student Readiness:** Student readiness to adapt to these skills can vary, making it challenging to effectively tackle all levels.
- **Time Constraints:** Finding time in the curriculum for skill development with quality content may be a limitation. (Michiel Doorman, Paul Drijvers, Truus Dekker, Marja van den Heuvel-Panhuizen, Jan de Lange, Monica Wijers, 2007)

Suggestions for Improving the Integration of Problem-Solving Skills in the Mathematics Curriculum

The following best practices will help for the practical integration of problem-solving skills in the mathematics curriculum and make the students equipped with problem-solving skills.

- Divide the problem-solving skills into different sub-key competencies that can be easily teachable to all age groups.
- Prepare real-life scenarios and problems related to all the mathematics topics and list out the technology and tools that can help the smooth integration.
- Use very attractive traditional or modern games that make problem-solving more engaging and enjoyable.
- Include lengthy complex projects that needed research and enquiry in the teaching and learning process that need critical thinking, collaboration and proper communication for a long time (weeks)
- Provide special care and differentiated instructions for those who struggle with all the sub-skills such as critical thinking, collaboration, communication etc. The language barrier also should be considered while presenting the scenario before the students.

- Keep curricular connections with other subjects such as physics, economics, commerce etc so that the solutions can be found from different dimensions.
- Frequently conduct professional development sessions to educate the teachers on how to select suitable sub-skills for each lesson, how to prepare matching problem-solving scenarios and use modern tools and techniques that enable easy problem-solving skills practice.
- Prepare unit-wise checklist skills and sub-skills and record the performance of the students regularly so that the teacher can identify the weaker area of each student and provide feedback.
- By implementing these strategies, math teachers can better equip students with the problem-solving skills needed in the 21st century.

Conclusion

21st-century skills, particularly problem-solving skills should be included in the Mathematics Curriculum for preparing students to be successful in the modern world that is changing quickly. As a subject that student's study from the very beginning of their school days, proper integration of the skills according to their physical and cognitive development stages helps to develop problem-solving skills gradually. Educators have a significant role in developing these skills and there should be a proper framework to eliminate the challenges they face in the integration. To conclude, the subject of mathematics is a very effective platform for developing problem-solving skills in students and making them successful citizens of the country and flexible problem-solvers in the constantly changing world.

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