

Problem Solving Method in Teaching of Mathematics (Trigonometry) at Secondary Stage

Ms. Preeti Anand

Abstract

This research examines the impact of the problem-solving approach on improving performance in Mathematics among secondary school students. Drawing on established problem-solving models, including variations of Polya's well-known four-step strategy (comprehending the problem, planning a solution, executing the plan, and reviewing the results), the study investigates how the structured use of such techniques influences students' conceptual grasp and academic success in Mathematics.

Adopting a quantitative research design, the study utilizes a sample of secondary-level learners and applies both descriptive statistics and regression analysis to assess the relationship between problem-solving instruction and academic performance. The results indicate a strong positive correlation, showing that implementing problem-solving methods significantly enhances student achievement. This improvement is attributed to the promotion of deeper understanding, strategic reasoning, and the ability to interrelate mathematical concepts.

Furthermore, the study finds that problem-solving strategies contribute to more favourable student attitudes toward Mathematics and foster the development of higher-order thinking skills. These skills are vital for addressing complex problems both in academic settings and real-life scenarios. The findings emphasize the value of embedding problem-solving techniques into the secondary Mathematics curriculum to improve educational outcomes and better equip students for future mathematical challenges.

Problem solving method refers to a structured, step-by-step approach used to identify solutions to specific challenges or issues. It's a way of thinking and working through problems methodically to reach a resolution. This method is used in everyday life, education, business, engineering, science, and more.

Keywords: Problem-Solving Method, Mathematics Education, Academic Achievement, Conceptual Understanding, Quantitative Research, Higher-Order Thinking

Introduction

This research involved two groups, **each comprising 20 students, who were randomly selected from two separate Grade 10 sections at Ramakrishna Senior Secondary School**, located in Vikaspuri, New Delhi. The institution is known for its inclusive approach to education and serves a wide-ranging student body from the surrounding neighbourhood, reflecting a mix of cultural, social, and academic backgrounds. This diversity provided a rich context for evaluating the effectiveness of the teaching method under study.

Mathematics is more than a collection of numbers, symbols, and formulas—it is a foundational discipline that nurtures logical reasoning, analytical thinking, and practical problem-solving abilities. Despite its significance, many secondary-level students struggle to grasp mathematical concepts, often leading to poor performance in assessments. This persistent issue has urged educators and researchers to seek innovative teaching strategies that can make Mathematics more engaging and comprehensible.

Ms. Preeti Anand, TGT (Maths), Ramakrishna Sr. Sec. School, Vikas Puri, New Delhi.

One such approach gaining recognition is the **problem-solving method** of teaching Mathematics. Unlike traditional instructional methods that emphasize memorization and repetitive procedures, the problem-solving approach fosters active student participation, critical thinking, and contextual application of knowledge. It encourages learners to explore concepts, pose and test hypotheses, reflect on outcomes, and develop deeper conceptual understanding. This method not only enhances academic performance but also builds learners' confidence and independence in approaching mathematical problems.

This research paper investigates the effectiveness of the problem-solving method in teaching **Trigonometry** to Grade 10 students. The study aims to evaluate whether **this instructional strategy significantly improves students' understanding, reasoning skills, and performance when compared to conventional teaching methods.**

Research Objectives

1. **To identify** specific problem-solving strategies that contribute most to students' success in Trigonometry.
2. **To assess** the effectiveness of the problem-solving method in improving students' understanding of trigonometric concepts.
3. **To contrast** the academic performance of Grade 10 learners taught through the problem-solving method with performance when the same learners taught through conventional approach.
4. **To investigate** students' attitudes and engagement towards learning Trigonometry when taught using the problem-solving method.

General Steps followed in Problem Solving Method:

1. **Identify the Problem**
Clearly understand and define what the actual problem is.
2. **Gather Information**
Collect relevant data, facts, and context related to the problem.
3. **Analyze the Problem**
Break the problem down into smaller parts and identify root causes.
4. **Generate Possible Solutions**
Brainstorm multiple ways to address or solve the problem.
5. **Evaluate and Select the Best Solution**
Compare options, considering pros, cons, risks, and resources.
6. **Implement the Solution**
Put the chosen solution into action with a clear plan.
7. **Monitor and Evaluate the Results**
Check if the solution worked. If not, make adjustments or try another approach.

Hypotheses:

Null Hypotheses:

H_{01} : There is no significant difference in the Mathematics performance of Class 10 students taught using the problem-solving method and those taught using traditional methods.

H_{02} : There is no significant difference in conceptual understanding of mathematical concepts between students taught through problem-solving and those taught through traditional instruction.

H_{03} : The problem-solving method has no significant effect on students' engagement or attitude toward learning Mathematics in Grade 10.

Research Hypothesis / Alternative Hypothesis:

H_A : "The use of the problem-solving method in teaching Trigonometry significantly enhances the conceptual understanding and problem-solving skills of Class 10 students compared to traditional lecture-based instruction."

Methodology

Problem-Solving Strategies for teaching Trigonometry at Secondary Stage

Research Design

This study follows a **pre-experimental (pre-test) and post-test design**. The aim is to evaluate the effectiveness of the problem-solving method in teaching Trigonometry by measuring the academic performance of two groups of Grade 10 learners before and after the intervention.

Participants

The participants of this study consisted of **Grade 10 students** from Ramakrishna Senior Secondary School. A total of **40 students (two groups of 20 students each)** from two different sections were selected using purposive sampling.

Instructional Procedure

The teaching intervention was carried out over a period of **4 weeks**, covering essential topics in Trigonometry from the Grade 10 Mathematics syllabus. All students received instruction first using conventional approach and gave a pre- test and then using the problem-solving method during the research followed by a post – test.

Lessons were designed to incorporate various **problem-solving strategies**, such as:

Real-life application problems:

- 1) Architecture: Calculating roof heights using elevation angles
- 2) Navigation: Finding distances between two points using angles
- 3) Surveying: Measuring inapproachable heights(e.g., trees, structures)

Group-based problem discussions

Group-based problem discussions are collaborative learning activities where students work in small groups to **analyze, discuss, and solve trigonometric problems**. The goal is to promote peer learning, deepen conceptual understanding, and build confidence in applying Trigonometry.

Benefits:

- Encourages **cooperative learning** and peer teaching
- Enhances **conceptual clarity** through multiple perspectives
- Builds **communication and reasoning skills**
- Increases **engagement and participation**
- Helps identify and correct **misconceptions**

Guided discovery and exploration

Guided discovery is a teaching strategy where the teacher leads students to uncover key trigonometric concepts through **carefully designed activities, questions, and explorations**—rather than directly telling them the rules or formulas. It encourages **active learning, critical thinking, and conceptual understanding**.

Trigonometry often involves abstract concepts and formulas (like $\sin$, $\cos$, $\tan$). Guided discovery helps students:

- Understand **why** formulas work, not just memorize them.
- See patterns and relationships in triangle geometry.
- Build a **deeper and longer-lasting understanding** of concepts.

Use of visual aids and hands-on activities

Visual aids and hands-on activities help bridge the gap between abstract trigonometric concepts and students' understanding by making learning **tangible, interactive, and visual**. Examples are :

Right Triangle Diagrams: Help students visualize opposite, adjacent, and hypotenuse sides in context.

Trigonometric Ratio Charts: Show values of sine, cosine, and tangent for standard angles (0° , 30° , 45° , 60° , 90°).

Animations or Videos: Show dynamic changes in angle size and corresponding ratio values.

Reflective questions and student-generated solutions

Reflective questions are open-ended prompts that guide students to:

- Think about their learning process
- Justify their reasoning

- Connect concepts
- Identify errors or alternative approaches

Examples in Trigonometry:

- “Why do you think sine increases as the angle increases from 0° to 90° ?”
- “What would happen to the value of cosine if the angle increases beyond 60° ?”
- “How can you decide whether to use sine, cosine, or tangent in a word problem?”
- “Is it possible for two triangles to have the same sine value but different side lengths? Why or why not?”
- “What mistake do you think someone might make when solving this problem, and how would you correct it?”

Benefits:

- Encourages **metacognition** (thinking about one’s own thinking).
- Improves **conceptual clarity**.
- Promotes **discussion and reasoning**, not just computation.

The goal was to actively involve students in the learning process and to encourage deeper understanding and critical thinking.

Data Collection Tools

1. **Pre-test and Post-test:** Designed to assess students’ knowledge and understanding of Trigonometry before and after the problem-solving intervention. Both the tests were standardised (verified by subject experts). Even the level of post Examination was kept difficult and highly competency based.
2. **Classroom Observation Checklist:** Used to monitor student engagement, participation, and response to the problem-solving approach during lessons.
3. **Student Feedback Questionnaire:** Collected qualitative data on students’ perceptions, challenges, and overall experience with the problem-solving method. Use performance tasks (e.g., “Measure the height of the school building, flagpole using Trigonometry”).

Data Analysis

Quantitative data from the pre-test and post-test were analyzed using **descriptive statistics** (mean and standard deviation) and **paired t-test** to determine whether there was a statistically significant improvement in students’ performance. Qualitative feedback from observations and standardised tests was analyzed thematically to support the interpretation of the results.

Paired t test results (FOR THE SAMPLE TAKEN FROM STUDENTS OF CLASS XA1) Refer Appendix I

Article 12

P value and statistical significance:

The two-tailed P value equals 0.0067

By conventional criteria, this difference is considered to be very statistically significant.

Confidence interval:

The mean of Test 2 - Test 1 equals -2.65

95% confidence interval of this difference: From -4.47 to -0.83

Intermediate values used in calculations:

$t = 3.0411$

$df = 19$

standard error of difference = 0.871

TEST	TEST 1	TEST2
Mean	13.05	15.70
SD	6.99	4.96
SEM	1.56	1.11
N	20	20

Paired t - test results (FOR THE SAMPLE TAKEN FROM STUDENTS OF CLASS XA3) Refer Appendix II

P value and statistical significance:

The two-tailed P value is less than 0.0001

By conventional criteria, this difference is considered to be extremely statistically significant.

Confidence interval:

The mean of Test2 minus Test 1 equals -5.85

95% confidence interval of this difference: From -8.06 to -3.64

Intermediate values used in calculations:

$t = 5.5346$

$df = 19$

standard error of difference = 1.057

TEST	TEST 1	TEST2
Mean	9.65	15.50
SD	5.22	3.43
SEM	1.17	0.77
N	20	20

Results

The analysis of the pre-test and post-test scores (Appendices I and II) revealed a **significant improvement** in students' performance after the implementation of the problem-solving method. The **mean score** of the post-test was notably higher than the mean score of the pre-test. The **paired t-test** results showed a statistically significant difference ($p < 0.05$), indicating that the increase in scores was not due to chance.

Observational data confirmed higher levels of **student engagement, participation, and collaboration** during lessons that incorporated problem-solving activities. Furthermore, student responses from the feedback questionnaire indicated that most learners found the method more **interactive, meaningful, and enjoyable** compared to previous learning experiences.

Common themes from student feedback included:

- Better understanding of trigonometric concepts through real-life applications.
- Increased confidence in solving problems independently.
- Greater interest and motivation to learn Mathematics.

Conclusion

The findings of this study suggest that the **problem-solving method is an effective instructional strategy** for enhancing the understanding and academic performance of Grade 10 students in Trigonometry. The method not only led to measurable improvement in test scores in both the groups but also fostered greater student engagement and positive attitudes toward learning. So, the null hypotheses has been rejected.

By **emphasizing critical thinking, real-world applications, and active student involvement**, the problem-solving approach addresses many of the limitations of traditional lecture-based instruction. Based on these outcomes, it is recommended that Mathematics educators incorporate problem-solving techniques into their regular classroom practice, especially when teaching abstract and complex topics like Trigonometry.

Further research could expand on this study by involving larger samples, longer intervention periods, and comparative analysis with other teaching methods to validate and generalize the results. The study of quasi-experimental **design** with a control group and an experimental group can also be considered.

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Appendices

APPENDIX - I

CLASS 10 A1, COMPARISON OF THE TWO TEST SCORES IN THE SAMPLE OF 20 STUDENTS

S. No.	Name	TEST1 (PRE -TEST) 25 marks	TEST2 (POST- TEST) 25 marks	DIFFERENCE
1	A	14	14	0
2	B	16	17	1
3	C	18	22	4
4	D	19	15	-4
5	E	23	24	1
6	F	8	12	4
7	G	13	11	-2
8	H	0	8	8
9	I	16	13	-3
10	J	17	19	2
11	K	0	11	11
12	L	12	15	3
13	M	12	14	2
14	N	11	16	5
15	O	13	16	3
16	P	22	25	3
17	Q	0	7	7
18	R	21	23	2
19	S	8	16	8
20	T	18	16	-2

APPENDIX - II**CLASS 10 A3, COMPARISON OF THE TWO TEST SCORES IN THE SAMPLE OF 20 STUDENTS**

S. No.	Name	TEST1 (PRE-TEST) 25 marks	TEST2 (POST -TEST) 25 marks	DIFFERENCE
1	A	7	15	8
2	B	11	16	5
3	C	18	23	5
4	D	2	15	13
5	E	9	21	12
6	F	15	14	-1
7	G	8	11	3
8	H	11	16	5
9	I	14	17	3
10	J	5	19	14
11	K	6	11	5
12	L	12	15	3
13	M	11	14	3
14	N	19	17	-2
15	O	2	10	8
16	P	0	11	11
17	Q	14	15	1
18	R	7	20	13
19	S	8	14	6
20	T	14	16	2