



Influence of Deductive Reasoning and Problem-Solving Ability on Achievement in Applied Mathematics of Secondary School Students

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ABSTRACT

Mathematics education emphasizes not only the mastery of content but also the development of higher-order thinking skills, such as deductive reasoning and problem-solving ability. These cognitive competencies are critical for students to engage in logical analysis and effectively approach complex mathematical tasks. This study explores the influence of deductive reasoning and problem-solving ability on Achievement in Applied Mathematics among secondary school students. Deductive reasoning involves drawing logically valid conclusions from given premises and is fundamental to mathematical proofs and structured problem-solving. Problem-solving ability, on the other hand, refers to a student's capacity to identify, analyze, and resolve problems using appropriate strategies. Using a quantitative research design, a representative sample of 300 secondary school students was assessed through standardized tests measuring Deductive Reasoning, Problem-Solving Ability, and Achievement in Applied Mathematics. Statistical techniques, including correlation and regression analysis, were applied to examine the relationship and predictive power of these variables on Achievement in Applied Mathematics. Findings of the study revealed that there is a moderate positive relationship between both Deductive reasoning and Achievement in Applied Mathematics and between Problem-Solving



Ability and Achievement in Applied Mathematics of Secondary School Students. The results of the study highlighted significant implications for designing curriculum, teaching strategies, and assessment practices in secondary mathematics education. Emphasizing these skills could help foster logical thinking and deeper understanding in students, ultimately enhancing their academic success in Mathematics.

Introduction

Mathematics is widely recognized as a foundational subject that nurtures logical reasoning, critical thinking, and problem-solving skills. As students' progress through their educational journey, especially in secondary school, their ability to understand and apply mathematical concepts becomes increasingly reliant on cognitive competencies such as deductive reasoning and problem-solving ability. These skills not only support Achievement in Applied Mathematics but also prepare students for real-world situations that demand analytical thinking.

Deductive reasoning refers to "a logical process in which a conclusion is based on the concordance of multiple premises that are generally assumed to be true" (Johnson-Laird, 2006). In mathematics, this skill is central to developing proofs, understanding theorems, and applying known principles to derive specific outcomes. For example, if all even numbers are divisible by 2, and 8 is an even number, we can deduce that 8 is divisible by 2. Such reasoning is critical for students to follow logical sequences and validate mathematical conclusions.

Problem-Solving Ability, as described by Polya (1945), is the capacity to use prior knowledge, creativity, and reasoning to find solutions to unfamiliar or challenging situations. In the mathematics classroom, this involves interpreting word problems, choosing appropriate strategies, and executing solution steps effectively. Problem-Solving is not merely about reaching the correct answer but also about understanding the process and being able to apply learned concepts in diverse contexts.

The National Council of Teachers of Mathematics (NCTM, 2000) emphasizes the importance of reasoning and problem-solving ability as essential components of mathematics learning. According to the NCTM, students must be equipped not only with procedural fluency but also with the ability to reason logically and solve problems meaningfully.



Deductive reasoning and problem-solving ability are interrelated. Effective problem-solvers often employ deductive reasoning when they eliminate possibilities, test hypotheses, or check the validity of their solutions. Conversely, developing deductive reasoning enhances a student's capacity to solve problems with structure and coherence. Despite their importance, these cognitive skills are not always explicitly taught or assessed in traditional mathematics instruction, which often emphasizes rote learning and procedural practice.

Numerous studies have shown that students with strong reasoning and problem-solving ability perform better in Mathematics (Lester, 1994; Mayer, 1992). However, much of the existing research has focused on inductive reasoning, problem-solving ability and Achievement in Mathematics. There is a need to examine the influence of Deductive Reasoning and Problem-Solving Ability on Achievement in Applied Mathematics to better understand how these skills interact and contribute to student success in mastering abstract mathematical concepts and applying them meaningfully in real-life situations.

This study seeks to address the existing research gap by examining the relationship between Deductive Reasoning, Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students. The findings are expected to inform pedagogical strategies that promote cognitive skill development, with implications for curriculum design, teacher training, and student engagement in mathematics instruction.

Need and Significance of the Study

Mathematics education has long emphasized procedural fluency and content mastery. However, there is growing recognition that true mathematical competence involves more than the ability to compute; it requires the capacity to think logically and solve complex problems. As the world becomes increasingly data-driven and analytical, the demand for individuals who can reason deductively and solve problems effectively has intensified.

Deductive Reasoning and Problem-Solving Ability have emerged as two key competencies linked to academic success, especially in Mathematics. Despite this, many school systems do not explicitly nurture these skills, often due to curriculum constraints, lack of teacher training, or an overemphasis on standardized testing. This creates a gap between what students learn and the cognitive demands of real-life applications of Mathematics.



Research indicates that students with high deductive reasoning tend to excel in Mathematics because they can follow logical arguments, recognize patterns, and draw valid conclusions (Nisbett et al., 1987). Similarly, students who are proficient in problem-solving can tackle unfamiliar questions, adapt strategies, and persist through challenges. However, most studies have examined these skills separately and how they collectively influence Achievement in Mathematics.

This study addresses that gap by investigating the influence of Deductive Reasoning and Problem-Solving Ability on Achievement in Applied Mathematics of Secondary School Students. Understanding this relationship is crucial for developing effective teaching practices that foster these skills. If a positive correlation is found, educators could be encouraged to integrate logical reasoning exercises and real-world problem-solving activities into regular instruction.

The findings may also contribute to curriculum development by highlighting the importance of balancing conceptual understanding with strategic thinking. Teacher training programs could use these insights to prepare educators who can support students in developing cognitive flexibility and logical precision.

Furthermore, the study is significant in the Indian educational context, where Achievement in Applied Mathematics is often used as a key determinant for future academic and career opportunities. Enhancing students' deductive reasoning and problem-solving ability can not only improve achievement scores but also prepare learners for competitive exams, STEM careers, and life-long learning. Hence, it is imperative to undertake research that identifies and promotes instructional strategies which develop these cognitive abilities. The present study is designed to explore the influence of deductive reasoning and problem-solving ability on Achievement in Applied Mathematics at the Secondary School Level.

Research Questions

1. Does there exist any relationship between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students?
2. Does there exist any relationship between Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students?
3. Is Deductive Reasoning a significant predictor of Achievement in Applied Mathematics of Secondary School Students?



4. Is Problem-Solving Ability a significant predictor of Achievement in Applied Mathematics of Secondary School Students?

Statement of the Problem

Deductive Reasoning and Problem-Solving Ability are essential cognitive competencies that significantly influence students' achievement, particularly in Applied mathematics. Recognizing their potential impact, it becomes imperative to explore their role in enhancing Achievement in Applied Mathematics. In this context, the present study aims to examine the relationship between Deductive Reasoning and Achievement in Applied Mathematics, the relationship between Problem-Solving Ability and Achievement in Applied Mathematics, and the extent to which these two variables predict students' Achievement in Applied Mathematics Accordingly, the problem is stated as:

“Influence of Deductive Reasoning and Problem-Solving Ability on Achievement in Applied Mathematics of Secondary School Students.”

Objectives of the Study

1. To find out the relationship between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students.
2. To find out the relationship between Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students.
3. To find out whether Deductive Reasoning is a significant predictor of Achievement in Applied Mathematics of Secondary School Students.
4. To find out whether Problem-Solving Ability is a significant predictor of Achievement in Applied Mathematics of Secondary School Students.

Hypotheses of the Study

1. There exists a significant relationship between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students.
2. There exists a significant relationship between Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students.



3. Deductive Reasoning is a significant predictor of Achievement in Applied Mathematics of Secondary School Students.
4. Problem-Solving Ability is a significant predictor of Achievement in Applied Mathematics of Secondary School Students.

Review of Related Literature

Sandhya (2012) conducted a study on effect of Mathematics Self Concept on Problem-Solving Ability and Achievement in Mathematics of Secondary School Pupils. Major objective of the study was to find the effect of Mathematics Self Concept on Problem Solving Ability and Achievement in Mathematics. The sample of study consists of 300 pupils from different secondary schools in Kollam district. The study concluded that there exists significant relationship between the variables.

Shibi (2013) conducted a study on Mathematical Problem-Solving Ability, Academic Achievement in Mathematics and Intelligence among Secondary School students in Kerala. The sample consists of 200 students (78 girls and 122 boys) from different schools in Trivandrum district. The key objective of the study was to find the relationship between the variables. The study concluded that there exists a significant relationship between the variables.

Pathak (2013) conducted a study on problem solving ability among undergraduate mathematically gifted students. The sample comprised 40 mathematically gifted students (20 boys and 20 girls) from various colleges in Jabalpur. The study found that the overall problem-solving ability of these students was high. Furthermore, significant differences were observed in problem solving ability based on gender, mother's education, and the type of educational institution. However, no significant difference was found with respect to the father's educational background.

Stanley (2014) conducted a study on Achievement Motivation and Problem-Solving Ability in Mathematics of IX standard students in relation to their Sex and Type of School. The sample of study consists of 300 pupils from different schools in Pondicherry. The study concluded that there is a significant relationship between Achievement Motivation and Problem-Solving Ability.

Ayoub (2019) explored the effect of problem-solving strategies on students' Achievement in Mathematics using an experimental design. The findings of the study indicated that students taught



through problem-solving approaches performed significantly better than those taught via traditional methods.

Albaqawi (2023) conducted a study on inductive and deductive reasoning in mathematics among 500 Saudi female 8th-grade students in Hail. Using a survey method, the study found that students showed a low level of mathematical reasoning ($M = 3.88$), with inductive reasoning ($M = 2.24$) higher than deductive reasoning ($M = 1.64$). The study recommended integrating reasoning skills into mathematics curricula and emphasized the importance of enhancing both types of reasoning through targeted educational programs.

Hao, Liang, Qi, and Jiang (2024) conducted a study titled “Assessing Mathematical Deductive Reasoning Competence of Eighth-Grade Students from China” involving 58,532 students. The study developed an assessment framework based on PISA and TIMSS, incorporating four dimensions of Mathematical Deductive Reasoning Competence (MDRC): cognitive level, reasoning context, reasoning form, and reasoning content. Students were categorized into four MDRC levels, with results showing 30.8% at the highest level. Girls outperformed boys across all dimensions, though the differences were of low practical significance. Urban students scored significantly higher than rural students, with a greater proportion of rural students performing at the lowest level. The study proposed a useful framework for future assessments of deductive reasoning competence in both national and international contexts.

Methodology

Normative Survey Method was employed to investigate the influence of Deductive Reasoning and Problem-Solving Ability on Achievement in Applied Mathematics of Secondary School Students. The Population of the study is Secondary School Students of Kerala, following Kerala State Syllabus and the sample of the study consists of 300 Secondary School Students of class IX, from 6 secondary schools in Trivandrum District, selected through simple random sampling to ensure representation across the population. Data were collected using three instruments including a Deductive Reasoning Test, a Problem-Solving Ability Test, and an Achievements in Applied Mathematics Test. The Deductive Reasoning Test was developed using the components Premises, Syllogism, Inferences, Critical Thinking and Validity and Soundness, grounded on the Aristotle’s Logic Theory. The draft tool consisted of 50 items, which was refined to 42 items after item analysis. The reliability of the test was established using test-retest method, yielding a reliability coefficient of 0.85 and criterion validity index was 0.92. The Problem-Solving Ability Test was constructed using the components Decision Making, Thinking



(Convergent and Divergent Thinking), Logical Reasoning and Creativity based on Sternberg's (1999) theory of cognitive process. The draft tool consists of 60 items, which were reduced to 50 items in the final version. The reliability of the test was established using split half reliability method, with a reliability coefficient of 0.83 and the criterion validity index is 0.91. The Achievement in Applied Mathematics Test constructed using Objective of Cognitive domains of Revised Blooms Taxonomy. The draft tool consists of 30 questions, which were reduced to 21 items in the final version. The reliability of the test was established using test-retest method, yielding a reliability coefficient of 0.81 and the criterion validity index is 0.9.

Statistical Techniques Used

- Karl Pearson's Product Moment Correlation
- Simple Regression Analysis

Analysis and Interpretation of the Data Collected

Descriptive statistics of Deductive Reasoning, Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students

The descriptive statistics for Deductive Reasoning, Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students are presented in the following table:

Table 1

Descriptive Statistics of Deductive Reasoning, Problem Solving Ability and Achievement in Applied Mathematics of Secondary School Students

Variables	Mean	Standard Deviation	Skewness	Kurtosis
Deductive Reasoning	26.02	7.37	-0.80	0.0003
Problem-Solving Ability	22.58	10.15	-0.61	-0.311
Achievement in Applied Mathematics	26.9	8.04	-1.32	1.37

From the table presented above, the mean score for Deductive Reasoning is 26.02 with a standard deviation of 7.37, indicating a moderate level of performance with a fairly consistent spread of scores. The skewness value of -0.80 indicated a moderate negative skewness, meaning that more students scored



above the mean. The kurtosis value (0.0003) is close to zero, indicating a distribution that is approximately normal in terms of peakedness.

For Problem-Solving Ability, the mean is 22.58 and the standard deviation is 10.15, reflecting a wider variability in students' abilities. The skewness of -0.61 indicates a mild negative skewness, suggesting a tendency for more students to perform above average. The kurtosis value is -0.311, indicating that the distribution is slightly flatter than normal distribution (platykurtic).

In the case of Achievement in Applied Mathematics, the mean is 26.9 and the standard deviation is 8.04, indicating a moderate level of achievement. The skewness of -1.32 reveals a stronger negative skewness, meaning a significant number of students scored higher, with a few low scorers creating a longer tail on the left side. The kurtosis value is 1.37, indicates that the distribution is leptokurtic.

Relationship between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School students

In order to find out the nature of relationship between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students, the investigator used Karl Pearson's Product Moment Correlation and the details of *r*, *t*, *SE* and level of significance for total sample is given in the table.

Table 2

Relationship between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students

Group	N	r	t	SE _r	99% Confidence Interval	
					Upper Level	Lower level
Total	300	0.64	14.21	0.05	0.73	0.53

From the above table coefficient of correlation for total sample is 0.64. The 'r' lies between the confidence interval 0.73-0.53 at 0.01 levels. Hence it is significant at 0.01 levels. The significant 'r' indicates that there exists a true relationship between the Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students. The magnitude of 'r' reveals that the relationship between Deductive Reasoning and Achievement in Applied Mathematics is moderate and positive. This indicates that the students having Deductive Reasoning possess Achievement in Applied Mathematics.

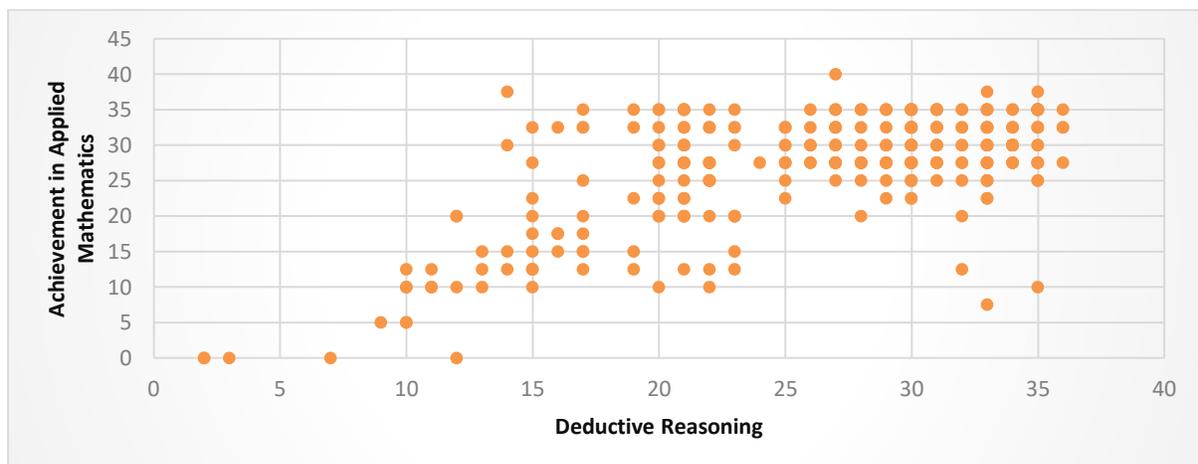
The obtained Fischer's t-value is 14.21 which is greater than the table value at 0.01 level. Hence it can be considered that there is a significance relationship between the two variables. Therefore, it can be concluded that the relationship exist between the variables is a moderate positive relationship.

Scatterplot showing Relationship between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students

A Scatter Diagram showing the relationship between Deductive Reasoning and Achievement in Applied Mathematics for total sample is given below.

Figure 1

Scatterplot showing between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students



In the figure the points are clustered round a line and also the increase in one variable is associated with an increase in the other variable, which shows that there is a direct, positive and moderate relationship exists between Deductive Reasoning and Achievement in Applied Mathematics of Secondary School Students.

Relationship between Problem Solving Ability and Achievement in Applied Mathematics of Secondary School students

In order to find out the nature of relationship between Problem Solving Ability and Achievement in Applied Mathematics, the investigator used Karl Pearson's Product Moment Coefficient of Correlation and the details of r, t, SE and level of significance for total sample is given in the table.

Table 3

Relationship between Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students

Group	N	r	t	SE _r	99%Confience Interval	
					Upper Level	Lower level
Total	300	0.62	13.0	0.04	0.72	0.51

From the above table coefficient of correlation for total sample is 0.62. The 'r' lies between the confidence interval 0.72-0.51 at 0.01 levels. Hence it is significant at 0.01 levels. The significant 'r' indicates that there exists true relationship between the Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students. The magnitude of 'r' reveals that the relationship between Problem-Solving Ability and Achievement in Applied Mathematics is moderate and positive. This indicates that the students having Problem-Solving Ability possess Achievement in Applied Mathematics.

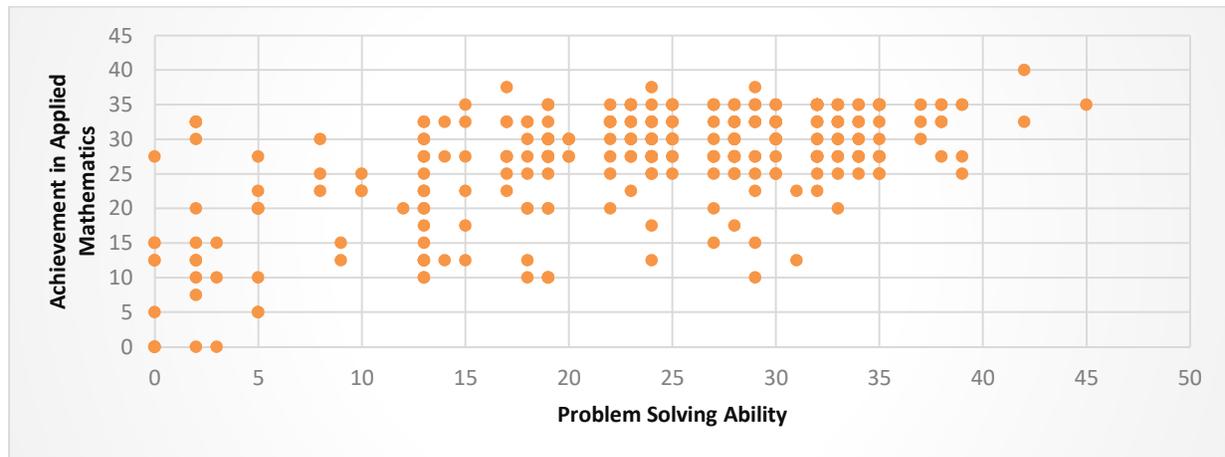
The obtained Fischer's t-value is 13.0 which is greater than the table value at 0.01 level (1.96). Hence it can be considered that there is a significance relationship between the two variables. Therefore, it can be concluded that the relationship exist between the variables is a moderate positive relationship.

Scatterplot showing Relationship between Problem Solving Ability and Achievement in Applied Mathematics of Secondary School Students

A Scatter Diagram showing the relationship between the variables Problem-Solving Ability and Achievement in Applied Mathematics for total sample is given below.

Figure 2

Scatterplot showing Relationship between Problem-Solving Ability and Achievement in Applied Mathematics of Secondary School Students



In the figure the points are clustered round a line and also the increase in one variable is associated with an increase in the other variable, which shows that there is a direct, positive and moderate relationship exists between Problem Solving Ability and Achievement in Applied Mathematics of Secondary School Students.

Simple Regression Analysis of Predictors of Achievement in Applied Mathematics of Secondary School Students

To determine whether Deductive Reasoning and Problem-Solving Ability are significant predictors of Achievement in Applied Mathematics of Secondary School Students, the investigator conducted simple regression analysis for each predictor variable and the result of the analysis is summarized below:

Table 4

Summary of Simple Regression Analysis

Predictor Variables	SE	t	p	R	R ²
Deductive Reasoning	0.05	14.21	< .01	0.602	0.362
Problem-Solving Ability	0.04	13.0	< .01	0.636	0.404

The results of the simple regression analysis indicate that both Deductive Reasoning and Problem-Solving Ability are significant predictors of Achievement in Applied Mathematics of secondary school students. For Deductive Reasoning, the regression analysis yielded a t-value of 14.21, which is statistically significant at 0.01 level. The correlation coefficient (R) is 0.602, indicating a moderate



positive relationship between deductive reasoning and Achievement in Applied Mathematics. The coefficient of determination (R^2) is 0.362, suggesting that 36.2% of the variance in students' Achievement in Applied Mathematics can be explained by their level of deductive reasoning. Similarly, the analysis for problem-solving ability revealed a significant t-value of 13.0 (at 0.01 level), with a correlation coefficient of 0.636, also indicating a moderate positive relationship. The R^2 value of 0.404 shows that 40.4% of the variance in Achievement in Applied Mathematics is accounted for by students' Problem-Solving Ability. These findings demonstrate that both Deductive Reasoning and Problem-Solving Ability are significant variables that contribute meaningfully to students' Achievement in Applied Mathematics. Therefore, integrating activities that promote these skills into mathematics instruction could enhance students' performance and engagement with the subject.

Major findings of the Study

- There is a statistically significant and moderately positive relationship between Deductive Reasoning and Achievement in Applied Mathematics of secondary school students.
- There is a statistically significant and moderately positive relationship between Problem-Solving Ability and Achievement in Applied Mathematics of secondary school students.
- Deductive reasoning is a significant predictor of Achievement in Applied Mathematics of secondary school students
- Problem-solving ability is a significant predictor of Achievement in Applied Mathematics of secondary school students

Educational Implications of the Study

The findings of this study clearly indicate that Deductive Reasoning and Problem-Solving Ability play a significant role in predicting and enhancing Achievement in Applied Mathematics of secondary school students. Based on these results, the following educational implications are drawn:

1. The study highlights the strong role of Deductive Reasoning and Problem-Solving ability in Achievement in Mathematics. Therefore, curriculum planners should integrate explicit training in these skills within mathematics textbooks and classroom activities.



2. Teachers should move beyond rote learning and adopt activity-based and inquiry-driven strategies that promote logical deduction and structured problem-solving, especially at the secondary school level.
3. Continuous training programs should be provided to mathematics teachers to help them incorporate strategies that enhance deductive reasoning and critical thinking among learners.
4. To develop contextual reasoning, classroom problems should be rooted in real-life or environmental situations that require logical application of concepts, fostering deeper understanding and long-term retention.
5. Since there is variability in student abilities (as indicated by the standard deviations), teachers should adopt differentiated instructional approaches to cater to students with varied levels of reasoning and problem-solving skills.
6. Schools should regularly assess students' reasoning and problem-solving abilities using diagnostic tools to identify gaps and plan remedial or enrichment programs accordingly.
7. Students should be encouraged to reflect on their reasoning strategies during problem-solving, helping them become aware of logical errors and refine their thinking processes.
8. Organizing math fairs, quiz competitions, puzzles, and logic games can provide informal yet effective platforms to nurture reasoning and problem-solving outside the regular classroom environment.
9. By systematically developing deductive reasoning and problem-solving skills, students may gain confidence in mathematics, thereby reducing math-related anxiety and improving overall academic outcomes.

Conclusion

The study concludes that both Deductive Reasoning and Problem-Solving Ability are moderately and positively related to Achievement in Applied Mathematics. These cognitive skills are significant predictors of Achievement in Applied Mathematics. Enhancing them can improve students' mathematical outcomes. Traditional teaching should be replaced with strategies that foster deductive reasoning and problem-solving ability since integrating these skills into instruction is essential for holistic student



development. Moreover, Teachers and policymakers must work together to integrate these skills through innovative pedagogy and enriched learning environments.

Delimitations and Limitations of the Study

- The study was confined to Class IX students from selected secondary schools in the Trivandrum district of Kerala. Therefore, the findings may not be generalized to students in other regions or states.
- Although the sample size of 300 is statistically adequate, it may not fully represent the diversity of all secondary school students, especially in terms of socio-economic status, language background, and school types (government, private, aided).
- The tools used to measure deductive reasoning and problem-solving ability were developed and validated by the investigator. Despite establishing reliability and validity, some subjective bias may still influence students' responses.
- Achievement in Applied Mathematics was measured using students' annual examination scores, which may not reflect their true understanding or potential due to test anxiety, varying school standards, or exam-oriented teaching.
- The study adopted a normative survey method (cross-sectional design), which limits the ability to establish causal relationships between the variables.
- The study did not account for other potential influencing factors such as teacher quality, classroom environment, parental support, or individual learning styles, which may have impacted students' Achievement in Applied Mathematics.

Recommendations for further Research

- Future studies can be conducted in other districts, states, or countries to examine whether the relationship between deductive reasoning, problem-solving ability, and Achievement in Applied Mathematics holds across different educational and cultural settings.
- Long-term studies may be undertaken to track the development of deductive reasoning and problem-solving ability over time and their sustained impact on Achievement in Applied Mathematics.



- Researchers may design experimental or quasi-experimental studies to test the effectiveness of specific teaching strategies or interventions aimed at improving deductive reasoning and problem-solving ability in mathematics classrooms.
- Comparative studies involving primary, secondary, and higher secondary students could provide insights into how these cognitive skills evolve with age and education level.
- Future research may include other influencing factors such as critical thinking, mathematical anxiety, motivation, parental involvement, or teacher effectiveness to get a more comprehensive understanding of Achievement in Applied Mathematics.
- Incorporating qualitative methods such as interviews, classroom observations, or case studies may yield deeper insights into how students apply creative and problem-solving skills in real learning situations.
- Studies can also focus on evaluating the impact of curriculum reforms, teaching aids, or teacher training programs aimed at fostering higher order thinking skills in mathematics education.

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