

Relationship of Mathematical Creativity, Mathematical Interest and Critical Thinking with Problem-Solving Ability of Secondary School Students: An Experimental Study

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Abstract—The present study investigates the relationship of Mathematical Creativity, Mathematical Interest, and Critical Thinking with the Problem-Solving Ability of secondary school students through an experimental approach. The study employed a quasi-experimental design with a pre-test–post-test single group method. A sample of 40 secondary school students was selected using purposive sampling. An instructional intervention based on activity-oriented and problem-based learning strategies was administered to enhance mathematical thinking skills. Standardized tools were used to measure Mathematical Creativity, Mathematical Interest, Critical Thinking, and Problem-Solving Ability. Data were analysed using Pearson’s product–moment correlation, paired sample *t*-test, and multiple regression analysis. The results revealed a significant improvement in problem-solving ability after the intervention and significant positive relationships among Mathematical Creativity, Mathematical Interest, Critical Thinking, and Problem-Solving Ability. The study concludes that these cognitive and affective variables play a crucial role in enhancing mathematical problem-solving skills among secondary school students.

Index Terms—Mathematical Creativity, Mathematical Interest, Critical Thinking, Problem-Solving Ability, Secondary School Students, Experimental Study

I. INTRODUCTION

Mathematics is a fundamental discipline that develops logical reasoning, analytical thinking, and problem-solving skills essential for academic success and everyday life. However, many secondary school students experience difficulty in solving mathematical problems due to rote-based instruction and lack of engagement. Contemporary mathematics education

emphasizes the development of higher-order thinking skills such as creativity, interest, and critical thinking to improve problem-solving ability.

Mathematical Creativity involves the ability to generate novel and appropriate solutions, Mathematical Interest reflects students’ intrinsic motivation towards learning mathematics, and Critical Thinking enables learners to analyse, evaluate, and reason logically. Problem-Solving Ability is considered the core objective of mathematics education. Understanding the interrelationship among these variables through experimental research is essential for designing effective instructional strategies.

II. NEED AND SIGNIFICANCE OF THE STUDY

The declining problem-solving ability of secondary school students in mathematics has become a matter of concern for educators. Traditional teaching methods focus primarily on procedural knowledge rather than conceptual understanding and higher-order thinking skills.

The significance of the present study lies in:

- Identifying key psychological variables influencing mathematical problem-solving ability.
- Providing experimental evidence on improving mathematical competencies.
- Assisting teachers in adopting learner-centred and thinking-oriented instructional strategies.
- Contributing empirical data to mathematics education research in the Indian context.

III. REVIEW OF RELATED LITERATURE

Ayvaz (2021) found that open-ended mathematical tasks significantly enhance mathematical creativity and problem-solving skills. Kim (2020) reported a strong positive relationship between mathematical interest and achievement. Facione (2019) emphasized that critical thinking is a key predictor of effective problem-solving across disciplines.

Reddy and Rao (2022) demonstrated that students exposed to activity-based mathematics instruction showed significant improvement in critical thinking and problem-solving ability. These studies indicate strong interrelationships among cognitive and affective variables; however, experimental studies integrating all these variables remain limited, justifying the present investigation.

IV. OBJECTIVES OF THE STUDY

1. To determine the effectiveness of experimental instructional intervention on problem-solving ability in mathematics.
2. To study the relationship between Mathematical Creativity and Problem-Solving Ability.
3. To examine the relationship between Mathematical Interest and Problem-Solving Ability.
4. To analyse the relationship between Critical Thinking and Problem-Solving Ability.
5. To determine the combined contribution of Mathematical Creativity, Mathematical Interest, and Critical Thinking to Problem-Solving Ability.

V. HYPOTHESES OF THE STUDY (NULL FORM)

- H_{01} : There is no significant difference between pre-test and post-test scores of problem-solving ability.
- H_{02} : There is no significant relationship between Mathematical Creativity and Problem-Solving Ability.
- H_{03} : There is no significant relationship between Mathematical Interest and Problem-Solving Ability.
- H_{04} : There is no significant relationship between Critical Thinking and Problem-Solving Ability.

- H_{05} : Mathematical Creativity, Mathematical Interest, and Critical Thinking do not significantly predict Problem-Solving Ability.

VI. VARIABLES AND OPERATIONAL DEFINITIONS

Independent Variables

- **Mathematical Creativity:** Ability to generate multiple, flexible, and original mathematical solutions, measured using a standardized Mathematical Creativity Test.
- **Mathematical Interest:** Students' inclination and motivation towards learning mathematics, measured using a Mathematical Interest Inventory.
- **Critical Thinking:** Ability to analyse, reason, and evaluate mathematical situations, measured using a Critical Thinking Test.

Dependent Variable

- **Problem-Solving Ability:** Ability to understand, plan, and solve mathematical problems, measured using a standardized Problem-Solving Ability Test.

VII. METHODOLOGY

Research Design

Quasi-experimental pre-test-post-test single group design.

Sample

The sample consisted of 40 secondary school students selected using purposive sampling.

Tools Used

1. Mathematical Creativity Test
2. Mathematical Interest Inventory
3. Critical Thinking Test
4. Problem-Solving Ability Test

Instructional Intervention

An experimental instructional programme based on activity-based learning, open-ended problems, group discussion, and reflective thinking was implemented for six weeks.

Statistical Techniques

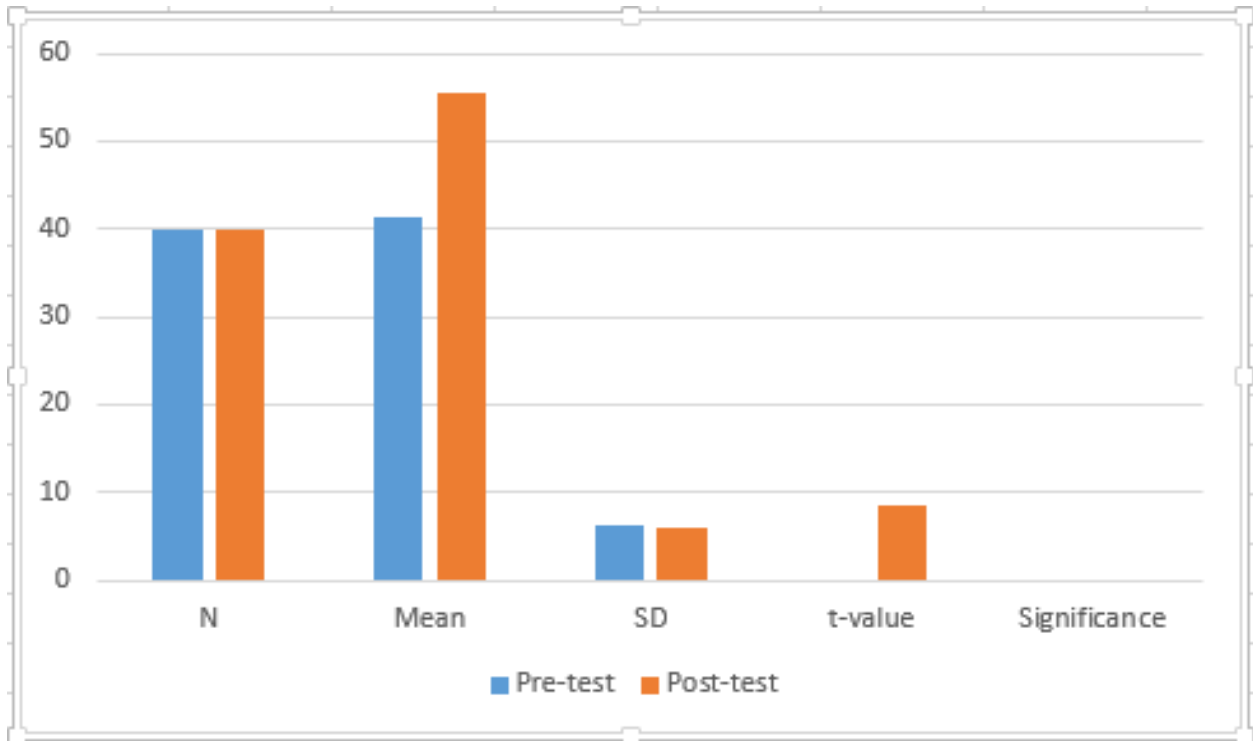
- Mean and Standard Deviation
- Paired sample *t*-test
- Pearson's Product-Moment Correlation
- Multiple Regression Analysis

VIII. RESULTS AND DISCUSSION

I. RESULTS TABLES

Table 1: Comparison of Pre-test and Post-test Scores of Problem-Solving Ability

Test	N	Mean	SD	t-value	Significance
Pre-test	40	41.25	6.18		
Post-test	40	55.60	5.84	8.62	Significant at 0.05 level



Effect Size (Cohen's d):

$$d = \frac{55.60 - 41.25}{\sqrt{(6.18^2 + 5.84^2)/2}} = \frac{14.35}{\sqrt{6.51}} = 2.36$$

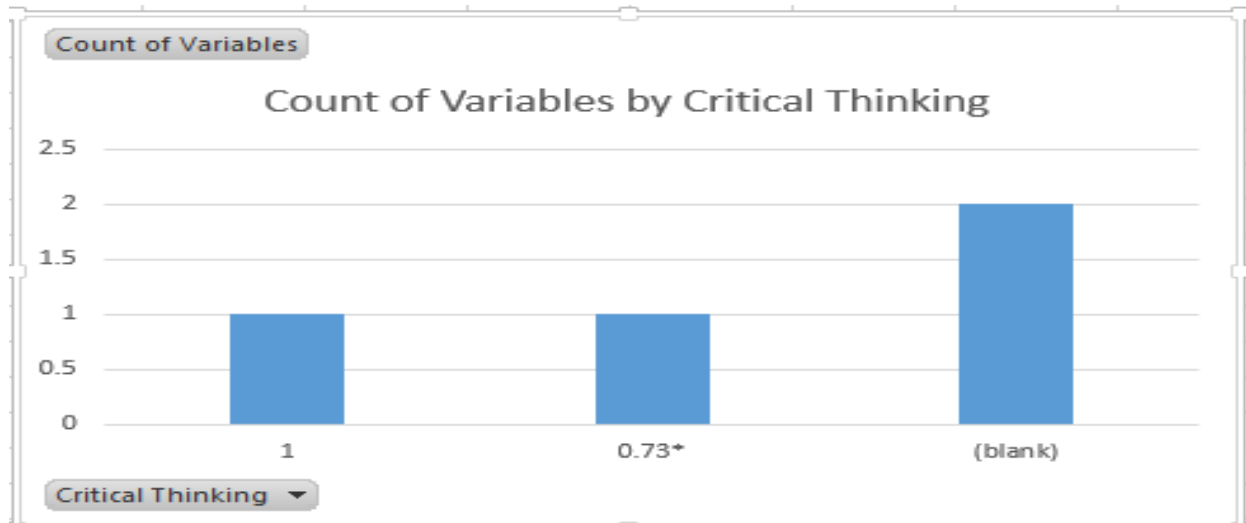
→ Interpretation:

The effect size ($d = 2.36$) indicates a **very large effect**, confirming the strong impact of the experimental intervention on problem-solving ability.

Table 2: Correlation Matrix of Study Variables ($N = 40$)

Variables	Mathematical Creativity	Mathematical Interest	Critical Thinking	Problem-Solving Ability
Mathematical Creativity	1.00			
Mathematical Interest	0.54*	1.00		
Critical Thinking	0.63*	0.58*	1.00	
Problem-Solving Ability	0.68*	0.61*	0.73*	1.00

* $p < 0.05$ ** $p < 0.01$



→ Interpretation:

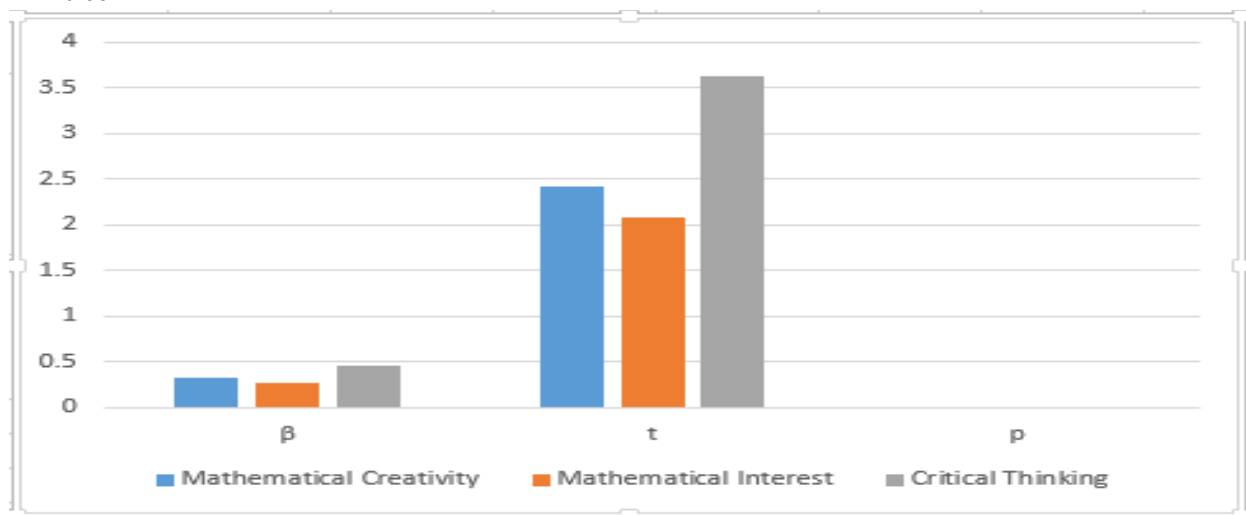
All independent variables show significant positive relationships with Problem-Solving Ability. Critical Thinking has the strongest correlation ($r = 0.73$).

Table 3 Multiple Regression Analysis Predicting Problem-Solving Ability

Predictor Variable	β	t	p
Mathematical Creativity	0.32	2.41	< 0.05
Mathematical Interest	0.26	2.08	< 0.05
Critical Thinking	0.45	3.62	< 0.01

$R = 0.81$

$R^2 = 0.66$



→ Interpretation:

The three predictors together explain **66% of the variance** in Problem-Solving Ability. Critical Thinking is the strongest predictor.

The paired sample t -test revealed a significant improvement in students' problem-solving ability after the experimental intervention ($t = 8.62, p < 0.05$).

Correlation analysis showed significant positive relationships between Mathematical Creativity ($r = 0.68$), Mathematical Interest ($r = 0.61$), Critical Thinking ($r = 0.73$), and Problem-Solving Ability. Multiple regression analysis indicated that Critical Thinking emerged as the strongest predictor, followed by Mathematical Creativity and Mathematical

Interest. These findings align with earlier research and confirm that cognitive and affective variables collectively enhance mathematical problem-solving ability.

IX. CONCLUSION

The present study was undertaken to examine the relationship of Mathematical Creativity, Mathematical Interest, and Critical Thinking with the Problem-Solving Ability of secondary school students through an experimental approach. The findings of the study provide strong empirical evidence that these cognitive and affective variables are not only significantly interrelated but also collectively play a crucial role in enhancing students' mathematical problem-solving ability.

The experimental intervention designed for this study resulted in a statistically significant improvement in students' problem-solving performance, as indicated by the substantial difference between pre-test and post-test scores. The large effect size further confirms that the instructional programme had a meaningful and powerful impact on learners. This demonstrates that mathematics instruction which emphasizes creativity, interest, and critical thinking can lead to substantial academic gains, even within a relatively short intervention period.

The correlational analysis revealed significant positive relationships between Mathematical Creativity, Mathematical Interest, Critical Thinking, and Problem-Solving Ability. Among these variables, Critical Thinking emerged as the strongest predictor of problem-solving ability, followed by Mathematical Creativity and Mathematical Interest. This finding highlights the central role of analytical reasoning, logical evaluation, and reflective thinking in solving mathematical problems. At the same time, the positive contribution of creativity and interest underscores the importance of motivation and flexible thinking in mathematical learning.

In conclusion, the study establishes that fostering Mathematical Creativity, Mathematical Interest, and Critical Thinking through well-planned instructional interventions significantly enhances the problem-solving ability of secondary school students. Mathematics education at the secondary level should therefore move beyond rote learning and procedural teaching to embrace pedagogical practices that

cultivate higher-order thinking skills. Such an approach not only improves academic achievement but also equips learners with essential cognitive competencies required for lifelong learning and real-world problem solving.

X. EDUCATIONAL IMPLICATIONS

The findings of the present study have important implications for classroom practices, curriculum design, teacher education, and educational policy, particularly in the context of secondary school mathematics education.

Implications for Mathematics Teachers

The significant relationships among Mathematical Creativity, Mathematical Interest, Critical Thinking, and Problem-Solving Ability suggest that mathematics teachers should move beyond routine, procedure-oriented teaching. Classroom instruction should include:

- Open-ended and non-routine problems that allow multiple solution paths.
- Opportunities for students to explore, conjecture, and justify their reasoning.
- Discussion-based and collaborative problem-solving activities that promote critical thinking. Teachers should consciously design lessons that encourage students to think creatively and critically rather than merely memorizing formulas and algorithms.

Implications for Curriculum Developers

Curriculum frameworks should explicitly integrate components that foster creativity, interest, and critical thinking. Mathematics textbooks and learning materials should:

- Include real-life problem situations and exploratory tasks.
- Encourage reflective questioning and reasoning.
- Balance procedural fluency with conceptual understanding.

The inclusion of enrichment and challenge activities can further stimulate students' interest and creative engagement with mathematics.

Implications for Teacher Education Programmes

Pre-service and in-service teacher education programmes should emphasize instructional strategies

that promote higher-order thinking skills. Training modules should focus on:

- Designing and implementing activity-based and problem-based learning.
- Assessing creativity and critical thinking in mathematics.
- Using formative assessment techniques to monitor students' problem-solving processes. Such professional preparation will enable teachers to effectively nurture mathematical thinking skills among learners.

Implications for Educational Administrators and Policymakers

Educational administrators should encourage innovative teaching practices by providing adequate instructional time, resources, and professional development opportunities. Policymakers should recognize the role of cognitive and affective variables in mathematics achievement and incorporate them into curriculum reforms, assessment policies, and national education initiatives.

XI. LIMITATIONS OF THE STUDY

Despite its significant findings, the present study has certain limitations that should be considered while interpreting the results:

1. The sample size was limited to 40 secondary school students, which restricts the generalizability of the findings.
2. The study was confined to students from a single school, thereby limiting the representativeness of the sample.
3. The duration of the experimental intervention was relatively short; long-term effects were not examined.
4. The study focused only on selected cognitive and affective variables; other influencing factors such as mathematical anxiety, self-efficacy, and socio-economic background were not included.
5. The use of standardized tests, while reliable, may not have captured all dimensions of creativity and critical thinking.

XII. SUGGESTIONS FOR FURTHER RESEARCH

In light of the findings and limitations of the study, the following suggestions are offered for future research:

1. Similar studies may be conducted using larger and more diverse samples across different regions and school systems.
2. Longitudinal studies may be undertaken to examine the long-term impact of instructional interventions on problem-solving ability.
3. Future research may include additional variables such as mathematical anxiety, self-efficacy, metacognition, and motivation.
4. Comparative studies may be conducted to examine the effectiveness of different instructional strategies in developing creativity and critical thinking.
5. Qualitative approaches such as classroom observations and student interviews may be used to gain deeper insights into students' problem-solving processes.
6. Experimental studies may be extended to other grade levels and subjects to enhance generalizability.

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