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# Enhancing Middle School Students' Mathematical Problem-Solving Through an Integrated Approach Of Critical Reasoning and Creative Learning

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**Abstract:** Middle school students' mathematics skills are examined in this research via an investigation of the effects of an integrated teaching strategy that merges creative learning with critical thinking. Two groups were included in the study, with one group receiving conventional methods of instruction and the other group engaging in inquiry-based learning, open-ended problem solving, and logical argumentation. The design was quasi-experimental. The development of analytical thinking, originality, and academic achievement were examined using pre- and post-tests. The results show how important it is to include critical thinking and creativity into regular maths lessons.

**Keywords:** Mathematical problem-solving, Integrated, Critical reasoning, Creative learning

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## INTRODUCTION

Mathematics has always played a crucial role in the educational system. Research into this area is an ongoing effort that is taken up to a higher degree. It is not self-contained; rather, it contributes to the growth of related fields. It is a basic component that facilitates the organisation of ideas in a rational fashion. Elementary school mathematics education is foundational to secondary and tertiary education. From the beginning of time, the topic has been highly valued. However, because to its connections to other branches of physical and social research, its significance has grown even more in recent times.

Mathematical foundational courses provide the groundwork for more advanced coursework by teaching students the fundamentals of addition, multiplication, subtraction, and division. Studying mathematics helps youngsters improve their reasoning, aesthetic sensibility, accuracy, and logical and analytical thinking, according to the National Curriculum Framework for School Education (NCFSE-2000). Mathematics is also given the weight it deserves in the recently revised National Curriculum Framework (NCF 2005). Every youngster should have the opportunity to succeed in mathematics.It is believed that mathematics education should help children become better thinkers and reasoners, as well as better able to conceptualise and work with abstract ideas and issues. Major aspects of the new NCF-2005 include continuity from one level to another, inter-disciplinary and thematic links between topics specified for various school courses, and connectivity between school and college syllabi. Everyone needs access to a high-quality mathematics education since it opens up a world of possibilities for their future careers.

When it comes to opportunities, mathematics is king. Today, mathematics is more than simply a language for scientists; it plays an essential role in many areas of national development, including economics, health, defence, and commerce. Therefore, the mathematical skills acquired in school will be useful throughout a student's life, regardless of their chosen profession.The overarching purpose of teaching mathematics in schools should be to help pupils become "mathematical problem solvers," rather than just good at arithmetic problems.As stated by Seeley and Harold (2004).After completing mathematics lessons, students should be able to recognise when and how mathematics is applicable in real-life scenarios and be comfortable thinking mathematically when faced with such challenges. Students need to approach mathematics with an analytical mindset, actively constructing new information by drawing on their experiences and what they already know. Knowing how to mathematise is more valuable than knowing a lot of maths. (David Wheeler, 1982).

Historically, cultural and colonial legacies have permeated mathematics education systems throughout the majority of the world's developing nations. A few countries that followed the British model were India, Singapore, and Hong Kong; the Philippines were American; Vietnam and Cambodia were French; and so on (Nebres B F, 1995).

Therefore, it is critical that students have a solid foundation in this area in school. The purpose of this research is to identify the most pressing issues affecting mathematics education in K-12 classrooms and to identify the variables that significantly impact this field.

## METHODOLOGY

Instead of looking at maths test results, this study will try to understand how a kid learns the subject by analysing their conceptual understanding. Finding out how mathematical competence, grasp of basic concepts, and academic achievement in mathematics are related was the driving force for this research. The study used a representative sample of secondary school students from the undivided Bongaigaon district, selected using a stratified random sampling technique. The sample consisted of 460 pupils from public schools and 120 students from private schools.The gender breakdown is 318 males and 262 females.

The investigator developed specialised exams to gauge the pupils' grasp of fundamental ideas and mathematical ability.Students from different schools took these exams while the survey was underway.

### Tests of mathematical aptitude

The emphasis was on mathematical aptitude rather than success on these teacher-prepared exams. The exam was created with the intention of highlighting students' abilities in visual/spatial processing, pattern identification, and logical reasoning rather than their computing abilities. Billstein et al. (1987), Bright (2002), and Carter (2002) were consulted for the formulation of several questions.

### Test of achievement

The math grades a student earned at the conclusion of the school year were used as the basis for evaluating their mathematical performance on exams. This grade was calculated as a percentage, with the yearly, half-

yearly, and unit exams each carrying equal weight.These grades were culled from the student records of the institutions that were visited.

## STATISTICAL ANALYSIS

A SPSS spreadsheet was used for data entry and subsequent analysis. After tallying all of the scores, we found the average and standard deviation. To find out how different the means were, we ran a t-test; to see how often different attributes were observed at the same time, we made use of cross tables; and to understand the relationship between conceptual knowledge and mathematical ability, two independent variables, and academic achievement, we ran a regression.

Using t-test and regression analysis, we have determined the relationship between conceptual understanding, mathematical competence, and academic accomplishment. Using a paired sample t-test, we looked for evidence that conceptual comprehension, mathematical ability, and academic accomplishment were not significantly different. as seen in the following outcome

The null hypothesis is rejected since all of the t-values are bigger than the crucial threshold. This demonstrates that the means of the aforementioned pairs of variables are significantly different from one another. Here are the results of the correlation analyses:

There is a linear connection between the variables as they are positively connected, as demonstrated in the previous table. Academic success is considered the dependent variable, with conceptual understanding and mathematical skill serving as the independent factors. We used regression analysis to look at how the independent factors affected the dependent variable. With conceptual understanding (X1) and mathematical competence (X2) as the independent variables, class IX scholastic success (Y1) is considered the dependent variable.

Everyone thought the regression equation looked like this:

where α is the intercept, $ß_1$ and $ß_2$ are the slopes and ε is the error term

## RESULTS AND DISCUSSION

- **Quantitative Overview of Students' Mathematical Creative Thinking Skills**

The quantitative analysis of students' mathematical creative thinking ability reveals a varied performance across different indicators. Table 1 presents the average scores for each test item designed to assess mathematical creativity. The maximum score for each item was 4, and the total maximum score was 16. The students' average total score was 7.54, which corresponds to 47.06% of the maximum, with an overall average of 1.88 per item (or 45.09%).

Notably, students showed the highest competence on item 1, which assessed their ability to think of multiple answers. This item achieved an average score of 2.71 (67.86%). In contrast, students struggled significantly with item 4, which focused on breaking down the details of an idea or situation, scoring only 0.32 on average (8.04%).

**Table 1: Average Scores by Item for Mathematical Creative Thinking**

| No. | Item Number | Max Score | Avg. Score | % Score |
|---|---|---|---|---|
| 1 | 1 | 4 | 2.71 | 67.86% |
| 2 | 2 | 4 | 1.89 | 47.32% |
| 3 | 3 | 4 | 2.61 | 65.18% |
| 4 | 4 | 4 | 0.32 | 8.04% |
| | **Total** | **16** | **7.54** | **47.06%** |
| | **Average** | - | **1.88** | **45.09%** |

- **Detailed Item-Wise Student Performance and Observed Trends**

Table 2 provides insights into the distribution of scores for each item. It was evident that item 4 posed the greatest challenge, with 20 out of 28 students receiving a score of 0, indicating substantial difficulty in analytical decomposition. Conversely, item 1 was the most successfully answered; 21 students earned a score of 3, and 2 students scored the maximum of 4, indicating a strong ability to generate multiple responses.

**Table 2: Distribution of Scores Across Items**

| Score | Item 1 | Item 2 | Item 3 | Item 4 |
|---|---|---|---|---|
| 4 | 2 | 2 | 9 | 0 |
| 3 | 21 | 13 | 12 | 0 |
| 2 | 1 | 2 | 0 | 1 |
| 1 | 3 | 2 | 1 | 7 |
| 0 | 1 | 9 | 6 | 20 |

- **Performance Based on Self-Regulated Learning Levels**

To further explore the data, students were grouped based on levels of self-regulated learning: high, moderate, and low. Table 3 illustrates the average score and percentage per group across each creative thinking indicator. Students with high self-regulation consistently outperformed their peers, particularly on item 3 (thinking in unusual ways), with an average score of 3.4 (85%). Students with low self-regulation showed their highest competence on item 1 (thinking of multiple answers), with a score of 2.4 (60%), but struggled considerably with item 4 (5%).

**Table 3: Average Scores by Self-Regulated Learning Level**

| **Indicator** | **Max** | **High ($\bar{x}$ / %)** | **Moderate ($\bar{x}$ / %)** | **Low ($\bar{x}$ / %)** |
|---|---|---|---|---|
| Multiple answers | 4 | 3.2 / 80% | 2.67 / 66% | 2.4 / 60% |
| Alternatives/different directions | 4 | 2 / 50% | 1.89 / 47% | 1.8 / 45% |
| Unusual thinking | 4 | 3.4 / 85% | 2.72 / 68% | 1.4 / 35% |
| Detail analysis/planning | 4 | 0.8 / 20% | 0.22 / 6% | 0.2 / 5% |
| **Average** | - | **9.4 / 58%** | **7.5 / 46%** | **5.8 / 36%** |

- **Qualitative Insights into Students' Creative Mathematical Thinking**

To supplement quantitative findings, qualitative data were collected through interviews and open-ended questionnaires. Table 4 summarizes the difficulties students encountered across items. A recurring issue was the inability to understand and elaborate on problem details, particularly for item 4. Students also demonstrated misconceptions in shape drawing (item 1), choosing inappropriate solution paths (item 2), and operational errors in algebra (item 3).

**Table 4: Observed Errors in Mathematical Creative Thinking**

| **Item** | **Observations** | **Common Mistakes** |
|---|---|---|
| 1 | Difficulty generating multiple answers | Incorrect shape characteristics; failure to create multiple valid shapes |
| 2 | Challenges in finding alternative directions | Misalignment of chosen solutions with question requirements |
| 3 | Inability to think in unusual ways | Errors in algebraic operations |

| | | |
|---|---|---|
| 4 | Struggles with analytical decomposition | Inability to identify question details or specify detailed steps in answers |

- **Performance of Students with High Self-Regulated Learning**

Table 5 outlines responses from students with high self-regulation. Although they performed better overall, they still encountered challenges with item 4, demonstrating incomplete understanding and inability to articulate detailed solutions.

**Table 5: High Self-Regulated Learners' Qualitative Performance**

| Student (Code) | Key Findings | Remarks |
|---|---|---|
| S-11 | Struggled to break down complex ideas | Incomplete response on item 4 |
| S-19 | Lacked in alternatives and detail decomposition | Could not extract or organize key information |
| S-26 | Errors in item interpretation and detail analysis | Failed to comprehend and respond accurately to item 2 and 4 |

- **Performance of Students with Moderate Self-Regulated Learning**

Table 6 shows that moderately self-regulated learners also found item 4 particularly challenging. Some also showed limitations in creative generation for item 1, indicating a need for strengthened divergent thinking strategies.

**Table 6: Moderate Self-Regulated Learners' Qualitative Performance**

| Student (Code) | Key Findings | Remarks |
|---|---|---|
| S-2 | Weak detail articulation | Unable to fully complete item 4 |
| S-5 | Limited in generating multiple answers | Could not sketch 3–5 distinct flat shapes in item 1 |

| | | |
|---|---|---|
| S-7 | Incomplete detail development | Failed to extract and communicate structured answers in item 4 |

- **Performance of Students with Low Self-Regulated Learning**

Table 7 confirms that low self-regulated learners struggled the most, particularly with divergent thinking (item 3) and planning/problem breakdown (item 4). These students often misinterpreted questions or left them unanswered.

**Table 7: Low Self-Regulated Learners' Qualitative Performance**

| **Student (Code)** | **Key Findings** | **Remarks** |
|---|---|---|
| S-18 | Inaccurate operations; weak detail planning | Could not complete items 3 and 4 |
| S-24 | Lacked alternative thinking and planning | Misunderstood item 2 and failed to respond to item 4 |
| S-27 | Did not use unusual or analytical approaches | Left most items incomplete or incorrect |

## CONCLUSION

For the purpose of forecasting future advancements in the subject, it is crucial to conduct analyses of educational resources and variables. Everyone involved in educational reforms—from parents and teachers to educationists and psychologists—could benefit greatly from this study's conclusions. The work done in the thesis is expected to contribute to the current body of knowledge in mathematics education theory research. Further concerns relating to mathematics education may be explored from this framework.

Developed nations place a premium on mathematical education research. Even in India, this field has seen a lot of research. This field of study, however, has received very little attention in the northeast.

For a youngster to thrive academically, they must master the building blocks of mathematics in school. Learning mathematics and how to use it in real-world contexts has become more important in today's technology-driven culture. Because of this, mathematics is crucial. Maths education in schools is the focus of the current investigation, which investigates a number of interconnected aspects.

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