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The Impact of Metacognition and Gender on Achievement in Mathematics of Elementary School Students of Himachal Pradesh

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Abstract
The purpose of this study was to explore the relationship of achievement in mathematics with metacognition and gender. The research method used was descriptive survey method. This study utilized simple random sampling technique to select 162 elementary school students. The tool used were, achievement test in mathematics developed by the author and metacognition scale developed by Singh and Bali in 2017. The statistical technique used were t-test and one way ANOVA. The results of the study indicated that metacognition significantly effects achievement in mathematics. Further, Tukey HSD test results show that achievement in mathematics improves from low to average metacognition, indicating a positive impact. However, achievement declines at high metacognition levels, suggesting that excessive metacognition may hinder achievement of students due to overthinking or mental fatigue. Moreover, the results demonstrate a significant difference in achievement in mathematics between male and female students.
Keywords: Achievement in mathematics, Gender and Metacognition.

1. Introduction

The National Education Policy (NEP) 2020 envisions a transformative educational landscape in India, prioritizing the cultivation of critical thinking, problem-solving and metacognitive abilities as essential components of holistic learning. This policy underscores a shift away from rote memorization, advocating for an education system that fosters reflective, self-regulated learners capable of navigating complex subjects like mathematics. Within this framework, the study of some factors influencing mathematics achievement in elementary school years becomes increasingly important, as mathematics forms a foundational component of cognitive development and academic success in future, not only within the subject itself but also across various disciplines that rely on analytical thinking and problem-solving (Cowan et al., 2011; Jordan et al., 2009).

Mathematics achievement during the elementary years is pivotal for students' future academic trajectories and the development of essential problem-solving skills that are indispensable for both academic and professional success. Beyond cognitive benefits, early success in mathematics can significantly boost students' confidence and cultivate a positive mindset towards learning. To design effective educational strategies and interventions, understanding the factors that influence mathematical achievement is

imperative. Metacognition and gender emerge as two key factors in this context, both playing substantial roles in shaping how students learn and perform in mathematics.

Metacognition, defined as the awareness and regulation of one's cognitive processes, has been identified as a crucial determinant of academic achievement, particularly in mathematics, where the ability to plan, monitor and evaluate one's own approach to problem-solving is vital (Schraw & Moshman, 1995). Some researches completed by Sonowal & Kalita (2017) and Malhotra & Gill (2024) indicates that students with strong metacognitive skills are better equipped to identify gaps in their understanding, adjust their learning strategies and seek help, when necessary, ultimately leading to improved academic performance (Goedhart, 2021). By fostering metacognitive skills from an early age, educators can empower students to become self-directed learners who are capable of navigating complex academic challenges with greater efficacy. Various studies indicate that although the gender gap in mathematics has narrowed, there are still disparities in performance and attitudes between male and female students (Hyde et al., 2008).

In the context of Himachal Pradesh, this study seeks to explore the effect of metacognition and gender on achievement in mathematics can provide valuable insights into the unique challenges and opportunities faced by elementary school students. This knowledge can inform future research exploring the underlying mechanisms and pave the way for the development of targeted interventions that promote equitable educational outcomes.

2. Review of related literature

The existing literature highlights a significant relationship between metacognition and academic achievement, with varying influences observed across gender and academic disciplines. Sawhney and Bansal (2015) found significant differences in academic achievement among undergraduate students with high and low levels of metacognition, as well as significant gender differences in metacognition levels. Similarly, Laistner (2016) reported that metacognitive strategies significantly boosted mathematics achievement, with greater benefits observed among female students, suggesting that gender-specific factors may influence the effectiveness of metacognitive strategies in improving learning outcomes. However, contrasting findings were presented by Sonowal and Kalita (2017), who identified a positive correlation between Metacognitive Awareness and Academic Achievement but found no significant gender differences in Metacognitive Awareness among students in Dibrugarh Town. Gupta (2017) also found no statistically significant differences in academic achievement and metacognitive abilities between male and female students. Ajisuksmo and Saputri (2017) further complicated the understanding by reporting no significant correlation between metacognitive skills and mathematics achievement, with variations in the influence of metacognition on mathematics achievement observed across different genders.

Recent studies are still investigating these dynamics. Malhotra and Gill (2024) demonstrated a positive relationship between overall metacognition scores and academic performance, highlighting that both knowledge of cognitive processes and regulation of cognition were positively correlated with academic success. This research emphasizes the importance of fostering metacognitive abilities to enhance learning experiences and academic outcomes. Similarly, David and Qasim (2024) found a positive correlation between math achievement and metacognitive skills across several Indian school boards, noting that while the implementation and evaluation abilities were consistent among boards, planning and monitoring skills varied. Their findings underscore the value of integrating metacognitive training into instructional strategies to boost mathematical performance.

3. Need and Significance of the study

In the Indian context, particularly in regions like Himachal Pradesh, there is a dearth of research investigating the influence of metacognition and gender on achievement in mathematics among elementary school students. Metacognition, the awareness and regulation of one's cognitive processes, is known to enhance achievements of students. However, its specific effects on achievement in mathematics, especially in relation to gender disparities, are underexplored. While existing literature suggests a general link between metacognition and academic performance, findings regarding its impact on achievement in mathematics, particularly concerning gender differences, are inconsistent and limited. By examining how varying levels of metacognition affect achievement in mathematics and whether these effects differ by gender, this research aims to inform targeted interventions that address diverse needs of students. By Aligning with the goals of National Education Policy 2020, promoting critical and reflective thinking, this study further seeks to guide interventions that support equitable academic success and nurture lifelong learners.

4. Problem Statement

The Impact of Metacognition and Gender on Achievement in Mathematics of Elementary School Students of Himachal Pradesh.

5. Objectives of the Study

1. To compare the achievement in mathematics of elementary school students with different levels of metacognition.
2. To assess the influence of gender on achievement in mathematics among elementary school students.

6. Research Hypotheses

1. There is no significant difference between the achievement in mathematics of elementary school students with different levels of metacognition.
2. There is no significant difference of achievement in mathematics between male and female elementary school students.

7. Limitations

This study is limited to only 8^{th} class students of district Hamirpur, Himachal Pradesh.

8. Methodology of the Study

8.1 Research method used

In this research, descriptive survey method was employed to study Achievement in Mathematics of Elementary School Students in relation to metacognition and Gender. The descriptive survey method is well-suited for this research as it provides a systematic way to collect and analyze data on the achievement in mathematics of elementary school students, taking into account the influences of metacognition and gender.

8.2 Sample of the study

The sample included 162 randomly selected students of 8^{th} class studying in Government Secondary and Senior Secondary schools of district Hamirpur, Himachal Pradesh.

9. Variables of the study

- **Dependent variable:** Achievement in Mathematics.
- **Independent variable:** Metacognition and Gender.

10. Operational Definitions of the Keywords

1. **Achievement in mathematics:** It refers to the total score of students in mathematics, typically assessed through standardized tests of achievements in mathematics reflecting their proficiency in mathematical concepts and problem-solving.
2. **Gender:** It refers to the biological classification of students as male or female.
3. **Metacognition:** It refers to the students' ability to plan, monitor and evaluate their cognitive strategies during mathematical problem-solving.

11 Tools Used

1. **Achievement test in mathematics-** An achievement test consisting of 26 items was developed to correspond with the eighth-grade FA-1 NCERT curriculum. It underwent thorough validation, including expert review for content validity and item analysis on a pilot sample of 35 students. The final test showed high reliability, with a test-retest reliability of 0.96 and a Cronbach's alpha of 0.79, indicating strong internal consistency.
2. **Metacognition Scale-** The Metacognition Scale, created by Singh and Bali in 2017, is well-suited for Indian contexts. The scale is based upon a five-point scale and consists of 50 items, demonstrating a test-retest reliability coefficient of 0.81.

12. Statistical Techniques used

t-test and one way ANOVA was utilized in the study to analyze the data.

13. Analysis and Interpretation of Results

Objective 1: To compare the achievement in mathematics of elementary school students with different levels of metacognition.

Table 1.1: Analysis of Variance (ANOVA) for Achievement in Mathematics by Level of Metacognition in Elementary School Students

Achievement in Mathematics					
Source of Variance	**Df**	**SS**	**MSS**	**F-Value**	**Remark**
Metacognition	2	574.87	287.44	7.09	P<0.01
Error	159	6446.05	40.54		
Total	161	7020.92			

From table 1.1, the F-value 7.09 indicates that metacognition has a significant effect on achievement in mathematics at 0.01 confidence level. In other words, there are statistically significant differences in the student's achievement in mathematics with varying levels of metacognition. Thus, the null hypothesis no. 1 that, "There is no significant difference between the achievement in mathematics of elementary school students with different levels of metacognition" is rejected.

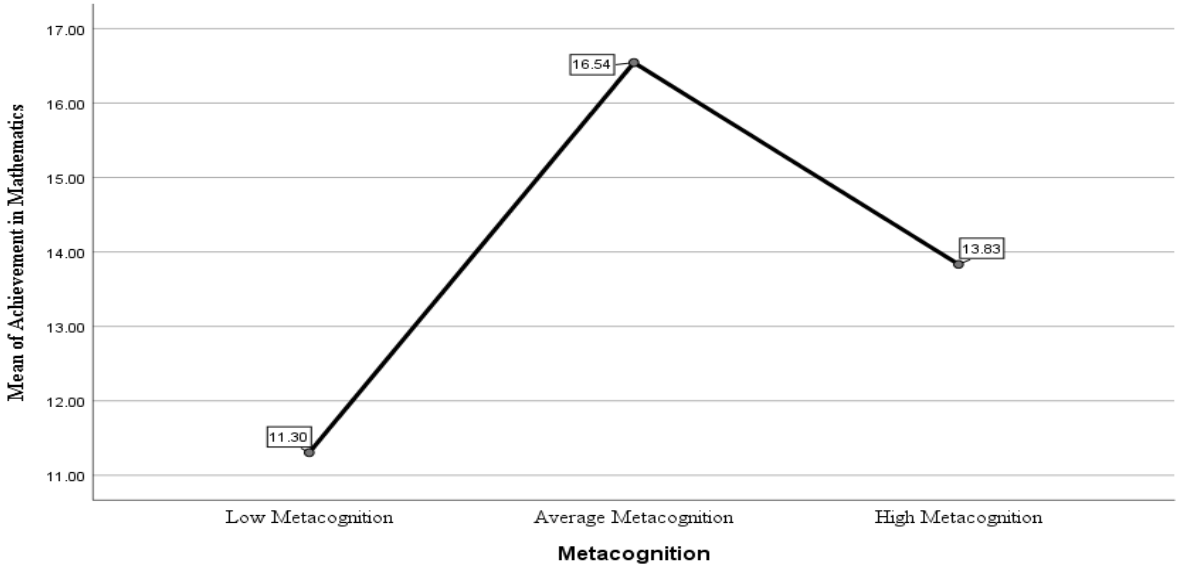
In order to know which level of metacognition had significantly higher mean score of Achievement in Mathematics, the data were further analysed with the help of Tukey HSD Test and the results are given in table 1.2.

Table 1.2: Tukey HSD Test Results Comparing Achievement in Mathematics Across Different Levels of Metacognition

Comparison group	Mean Difference	p-value	Significance
Average vs Low (Metacognition)	5.24	0.001	*
High vs Low (Metacognition)	2.53	0.506	NS
Average vs High (Metacognition)	2.71	0.339	NS
; Where * means Significant at 0.01 level and NS means non-significant at 0.05 level.			

According to Table 1.2, Post hoc comparisons using the Tukey HSD test indicated that the mean score for the low metacognition (M = 11.30, SD = 4.75) was significantly different from the average metacognition level (M = 16.54, SD = 6.67) (p = 0.001). However, the high metacognition level (M = 13.83, SD = 5.76) did not differ significantly from either the low or average level of metacognition (p > 0.05). This indicates that an increase from low to average metacognition improves achievements of students. As shown in Figure 1.

Figure 1: Mean Achievement in Mathematics Scores by Levels of Metacognition



The figure 1, illustrates the relationship between levels of metacognition (low, average, and high) and the mean achievement in mathematics. The mean achievement increases sharply from 11.30 (low metacognition) to 16.54 (average metacognition) but then drops to 13.83 at the high metacognition level. This

indicates that average metacognition is associated with higher achievement, while excessively high metacognition may not result in optimal achievement in mathematics.

Objective 2: To assess the influence of gender on achievement in mathematics among elementary school students.

Table 1.3: Independent Samples t-Test Comparing Mathematics Achievement Across Male and Female students.

Gender	N	M	SD	t-value	Remark
Male	88	14.35	6.42	2.67	p<0.01
Female	74	17.08	6.55		

From the table 1.3, it is evident that the t- value is 2.67 which is significant at 0.01 level with df = 160. It shows that the mean scores of achievement in mathematics of male and female students differ significantly. Thus, the null hypothesis no. 2 that, "there is no significant difference of achievement in mathematics between male and female elementary school students" is rejected. Additionally, the fact that the average score for female students (17.08) was considerably higher than the average score for male students (14.35) indicates that gender has a significant impact on achievement in mathematics.

14. Discussions of the Result

1. The findings of this study highlighted the significant effect of metacognition on achievement in mathematics of elementary school students, aligning with previous research by Sawhney and Bansal (2015), Laistner (2016) and Malhotra and Gill (2024). These studies support the idea that students with high metacognition skills tend to score better in mathematics. However, findings contrast with the results of Ajisuksmo and Saputri (2017) and Gupta (2017), who found no significant relationship among mathematics and achievement in mathematics. These differences could occur due to variations in research method, sample characteristics or educational contexts, suggesting the need for further research to clarify under which conditions metacognition most effectively enhances mathematical achievement of the students.

In addition to this Tukey HSD results indicates that, the sharp increase in achievement in mathematics from low to average level of metacognition shows the positive impact of average metacognition on achievement of students. However, the subsequent decline in achievement at the high metacognition suggests that overemphasis on metacognition might hinder achievement of students, possibly due to overthinking or metal fatigue.

2. The result of the t-test demonstrated a significant difference in achievement in mathematics between male and female students, consistent with findings of Sawhney and Bansal (2015), Laistner (2016) and Malhotra and Gill (2024). These studies suggest that gender differences may influence achievement in mathematics. However, this result contrasts with Sonowal and Kalita (2017), who found no significant difference. The inconsistency in findings highlights the need for further research to better understand the factors contributing to these gender differences. The contradictory results emphasize the need for further research to fully understand the different factors contributing to these gender disparities.

15. Educational Implications:

The findings of this study underscore the importance of fostering metacognitive skills in educational setti-

ngs. However, they also caution against overemphasizing metacognition, as it may lead to unintended negative effects due to cognitive overload. Teachers should aim to enhance students' metacognitive abilities through targeted instructional strategies, such as reflective practices, self-regulation techniques and problem-solving activities tailored to their developmental levels.

Additionally, the observed significant differences in mathematics achievement between male and female students also highlight the need for curriculum modifications and gender-sensitive interventions. These interventions should be designed to address the distinct learning needs of both male and female students, promoting equity and ensuring that all students have the opportunity to succeed in mathematics. By incorporating strategies that cater to diverse learning styles and challenges, educators can create a more inclusive and supportive learning environment for all students.

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